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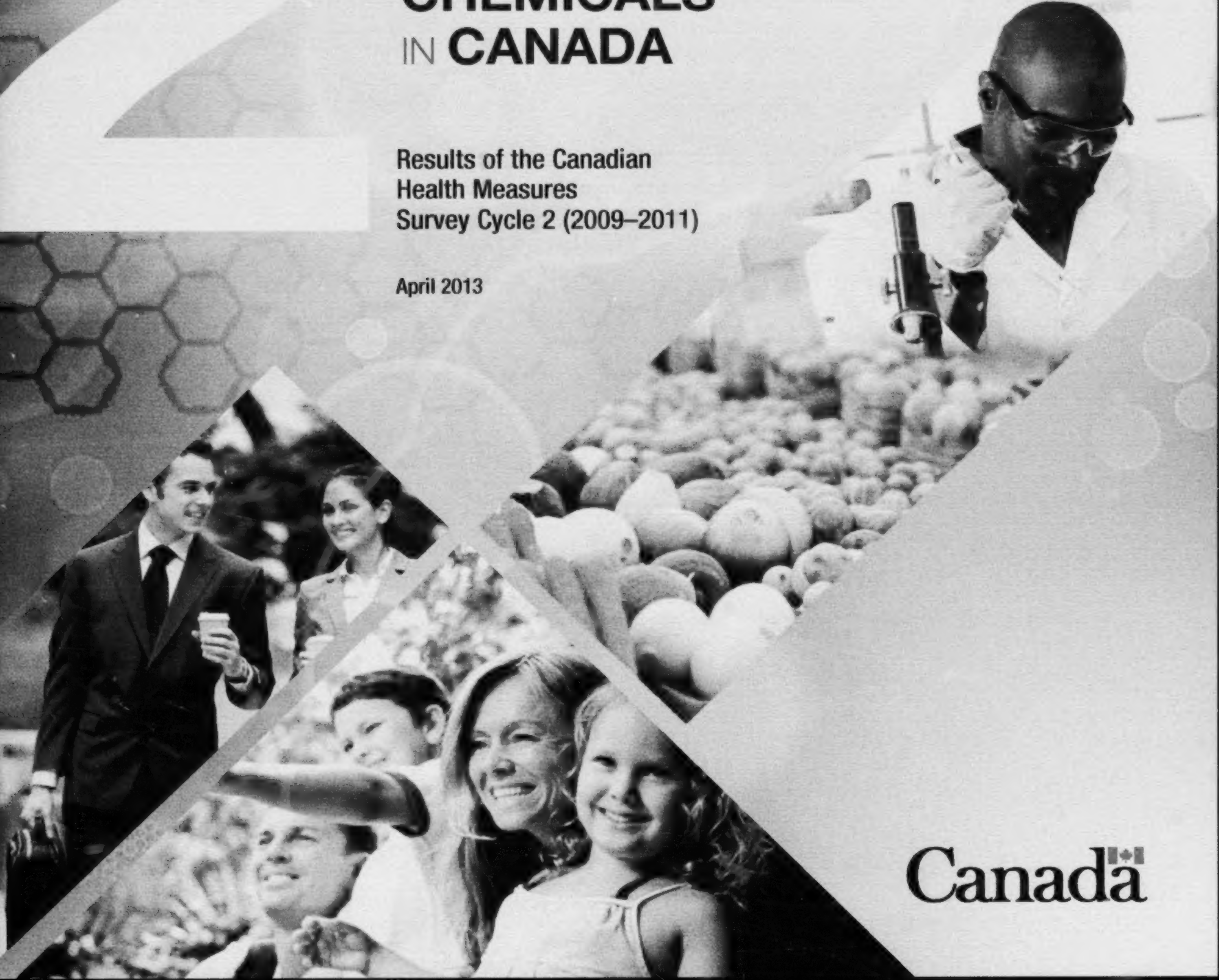
SECOND REPORT ON HUMAN BIOMONITORING OF ENVIRONMENTAL CHEMICALS IN CANADA

Results of the Canadian Health Measures Survey Cycle 2 (2009–2011)

April 2013



Canada

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INTRODUCTION

1

This *Second Report on Human Biomonitoring of Environmental Chemicals in Canada* presents national data on concentrations of environmental chemicals in Canadians. These data were collected as part of the Canadian Health Measures Survey (CHMS), an ongoing national direct health measures survey. Statistics Canada, in partnership with Health Canada and the Public Health Agency of Canada, launched the CHMS in 2007 to collect health and wellness data and biological specimens on a nationally representative sample of Canadians. Biological specimens were analyzed for indicators of health status, chronic and infectious diseases, nutritional status and environmental chemicals.

The CHMS biomonitoring component measures many environmental chemicals and/or their metabolites in blood and urine of survey participants. For the purposes of this report, an environmental chemical is defined as a chemical substance, either human-made or natural, that is present in the environment and to which humans may be exposed through media such as air, water, food, soil, dust, or consumer products.

The first *Report on Human Biomonitoring of Environmental Chemicals in Canada* was published in August 2010 and included baseline data for 81 of the environmental chemicals measured in cycle 1 (Health Canada, 2010). Data for cycle 1 of the CHMS were collected between March 2007 and February 2009 from approximately 5,600 Canadians aged 6 to 79 years at 15 sites across Canada.

The second report contains data from cycle 2 collected between August 2009 and November 2011 from approximately 6,400 Canadians aged 3 to 79 years at 18 sites across Canada. Cycle 2 includes 91 environmental chemicals of which 42 were also measured in cycle 1. A summary of the environmental chemicals measured in cycle 1 and cycle 2 of the CHMS is presented in Table 1.1. For a detailed list of the environmental chemicals measured in cycle 2, see Table 3.4.1.

Table 1.1

Summary of chemicals measured in cycle 1 (2007–2009) and cycle 2 (2009–2011) of the Canadian Health Measures Survey.

<table>
<tr><th>Cycle 1 (2007–2009)</th><th>Cycle 2 (2009–2011)</th></tr>
<tr><td>Organochlorines
Polybrominated flame retardants
Polychlorinated biphenyls</td><td></td></tr>
<tr><td colspan="2">Metals and trace elements
Chlorophenols
Environmental phenols and triclocarban
Nicotine metabolite
Perfluoroalkyl substances
Pesticides
Phthalate metabolites</td></tr>
<tr><td></td><td>Benzene metabolites
Polycyclic aromatic hydrocarbon metabolites</td></tr>
</table>

Collection for cycle 3 of the CHMS began in January 2012 and will be completed in late 2013. Planning for future cycles is under way.

In this report, the general CHMS survey design and implementation are described, with emphasis on the biomonitoring component. These sections are followed by descriptive summaries for each chemical, outlining the chemical's identity, common uses, occurrence in the environment, potential sources of exposure in the human population, toxicokinetics in the body, health effects, regulatory status, and existing Canadian biomonitoring data.

Data tables specific to each chemical follow each summary; the tables are broken down by age group and sex, and contain descriptive statistics on the distribution of blood and/or urine concentrations in the sample population. For the 49 new environmental chemicals measured in cycle 2, tables present baseline data for the Canadian population. For chemicals that were measured in both cycle 1 and cycle 2, data from both cycles are presented together in tables to allow for ease of comparison. Data for chemicals that were only measured in cycle 1 (Table 1.1) can be found in the first *Report on Human Biomonitoring of Environmental Chemicals in Canada* (Health Canada, 2010).

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Health Canada. (2010). Report on human biomonitoring of environmental chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 1 (2007–2009). Minister of Health, Ottawa, ON. Retrieved September 1, 2011, from www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/chms-ecms/index-eng.php

OBJECTIVES 2

The primary purpose of the *Second Report on Human Biomonitoring of Environmental Chemicals in Canada* is to provide human biomonitoring data to scientists and health and environment officials to aid in assessing exposure to environmental chemicals and in developing policies to reduce exposure to toxic chemicals for the protection of the health of Canadians.

Some specific uses of the information presented in this report include the following:

- to establish baseline concentrations of chemicals in Canadians that could allow for comparisons with subpopulations in Canada and with other countries;
- to establish baseline concentrations of chemicals to track trends in Canadians over time;
- to provide information for setting priorities and taking action to protect the health of Canadians and to protect Canadians from exposure to environmental chemicals;
- to assess the effectiveness of health and environmental risk management actions intended to reduce exposures and health risks from specific chemicals;
- to support future research on the potential links between exposure to certain chemicals and specific health effects; and
- to contribute to international monitoring programs, such as the Stockholm Convention on Persistent Organic Pollutants.

SURVEY DESIGN 3

The Canadian Health Measures Survey (CHMS) was designed as a cross-sectional survey to address important data gaps and limitations in existing health information in Canada. Its principal objective is to collect national-level baseline data on important indicators of Canadians' health status, including those pertaining to exposures to environmental chemicals. This information is important in understanding exposure to risk factors, detecting emerging trends in risk factors and exposures, and advancing health surveillance and research in Canada. Detailed descriptions of the CHMS rationale, survey design, sampling strategy, mobile examination centre (MEC) operations and logistics, as well as ethical, legal, and social issues for cycle 2, have been published previously (Giroux et al., 2013; Statistics Canada, 2013).

3.1 TARGET POPULATION

Cycle 2 of the CHMS targets the population aged 3 to 79 years living at home and residing in the 10 provinces and three territories. People living on reserves or in other Aboriginal settlements in the provinces, residents of institutions, full-time members of the Canadian Forces, persons living in certain remote areas, and persons living in areas with a low population density were excluded.

3.2 SAMPLE SIZE AND ALLOCATION

To meet the objective of producing reliable estimates at the national level by age group and sex, cycle 2 of the CHMS required a minimum sample of at least 5,700 participants. The participants were distributed among six age groups (3–5, 6–11, 12–19, 20–39, 40–59, and 60–79 years) and sex (except for 3–5 years), for a total of 11 groups. For the 3 to 5 year old age group, the survey was not designed to provide estimates for the individual sexes.

3.3 SAMPLING STRATEGY

To meet the requirements of the CHMS, a multi-stage sampling strategy was used.

3.3.1 Sampling of Collection Sites

The CHMS required participants to report to a mobile examination centre and be able to travel to the centre within a reasonable period of time. The Canadian Labour Force Survey sampling frame (Statistics Canada, 2008) was used to create 257 collection sites across the country. A geographic area with a population of at least 10,000 and a maximum participant travel distance of 100 kilometres (50 kilometres in urban areas and 100 kilometres in rural areas) were required for the location of collection sites. Areas not meeting these criteria were excluded. Nonetheless, the CHMS covers 96.3% of the Canadian population aged 3 to 79 years (Statistics Canada, 2013).

A larger number of collection sites would have optimized the precision of the estimates. However, the logistical and cost constraints associated with the use of MECs restricted the number of collection sites to 18. The 18 collection sites were selected from within the five standard regional boundaries used by Statistics Canada (Atlantic, Quebec, Ontario, Prairies [including Yellowknife], and British Columbia [including Whitehorse]); they were allocated to these regions in proportion to the size of the population. Although not every province and territory in Canada had a collection site, the CHMS sites were chosen to represent the Canadian population, east to west, including larger and smaller population densities. The collection sites selected for cycle 2 of the CHMS are listed in Table 3.3.1.1.

Table 3.3.1.1
Canadian Health Measures Survey cycle 2 (2009–2011) collection sites.

Atlantic	Quebec	Ontario	Prairies	British Columbia
• St. John's, N.L. • Colchester and Pictou Counties, N.S.	• Laval • South Montérégie • Gaspésie • North Shore Montréal	• Central and East Ottawa • South of Brantford • Southwest Toronto • East Toronto • Kingston • Oakville	• Edmonton, Alta. • Winnipeg, Man. • Calgary, Alta.	• Richmond • Central and East Kootenay • Coquitlam

3.3.2 Dwelling and Participant Sampling

The 2006 Canadian Census was used as the frame to select dwellings. Within each site, dwellings with known household composition at the time of the 2006 Census, updated with the most recent information from administrative files, were stratified by age of household residents at the time of the survey, with the six age-group strata corresponding to the CHMS cycle 2 age groups (3–5, 6–11, 12–19, 20–39, 40–59, 60–79 years). Within each site, a simple random sample of dwellings was selected in each stratum. Each selected dwelling was then contacted and asked to provide a list of current household members; this list was used to select the survey participants. One or two people were selected, depending on the household composition.

3.4 SELECTION OF ENVIRONMENTAL CHEMICALS

To determine the list of environmental chemicals to be included in cycle 2 of the CHMS, a national consultation process was initiated by Health Canada from May to June 2008. The primary mechanism of consultation was through a questionnaire distributed to key participants with expertise or interest in human biomonitoring of environmental chemicals; the purpose was to define specifically what should be measured in blood and urine samples in cycle 2 in the Canadian population. Key participants included various internal Health Canada branches and programs as well as a number of external groups, including other federal departments, provincial/territorial health and environment departments, industry groups, environment and health non-governmental organizations, and academics. Through this consultation, over 310 different chemicals and metabolites were nominated.

Selection was based on health risks; evidence of human exposure; existing data gaps; commitments under national and international treaties, conventions, and agreements; availability of standard laboratory analytical methods; and current and anticipated health policy development and implementations.

The following criteria were used as a general guide for identifying and selecting the environmental chemicals to include in the CHMS:

- seriousness of known or suspected health effects related to the substance;
- need for public health actions related to the substance;
- level of public concern about exposures and possible health effects related to the substance;
- evidence of exposure of the Canadian population to the substance;
- feasibility of collecting biological specimens in a national survey and associated burden on survey participants;
- availability and efficiency of laboratory analytical methods;
- costs of performing the test; and
- parity of selected chemicals with other national and international surveys and studies.

In addition, environmental chemicals from cycle 1 considered to be high priorities were carried forward into cycle 2. Ultimately, the list was narrowed by the volume of biospecimens available from survey participants to conduct the analyses. Blood volume is generally limited, and it is also required for analyses of chronic and infectious diseases and nutritional biomarkers. Thus, fewer environmental chemicals were measured in blood than in urine.

Some analytes were measured because the analytical method used, such as that used for the metals, provided results for additional chemicals with little or no additional biospecimen volume and cost; these included essential nutrients such as copper, molybdenum, selenium, and zinc, all of which are required for maintenance of good health. A full list of the chemicals measured in CHMS cycle 2 is presented in Table 3.4.1.

Table 3.4.1

Chemicals measured in the Canadian Health Measures Survey cycle 2 (2009–2011) including those also measured in cycle 1 (2007–2009).

Cycle 1 (2007–2009)		Cycle 2 (2009–2011)	
METALS AND TRACE ELEMENTS			
Antimony	Arsenic (total)	Cadmium	Copper
Lead	Mercury	Manganese	Molybdenum
Nickel	Selenium	Uranium	Vanadium
Zinc			
		Arsenic (speciated)	
		Arsenate	
		Arsenite	
		Arsenocholine and arsenobetaine	
		DMA (Dimethylarsinic acid)	
		MMA (Monomethylarsonic acid)	
		Cesium	Cobalt
		Fluoride	Silver
		Thallium	Tungsten

continued on the next page

Cycle 1 (2007–2009)	Cycle 2 (2009–2011)
CHLOROPHENOLS	
2,4-DCP (2,4-Dichlorophenol)	
	2,5-DCP (2,5-Dichlorophenol) 2,4,5-TCP (2,4,5-Trichlorophenol) 2,4,6-TCP (2,4,6-Trichlorophenol) PCP (Pentachlorophenol)
ENVIRONMENTAL PHENOLS AND TRICLOCARBAN	
Bisphenol A	
	Triclocarban Triclosan
NICOTINE METABOLITE	
Cotinine	
PERFLUOROALKYL SUBSTANCES	
PFHxS (Perfluorohexane sulfonate) PFOA (Perfluorooctanoic acid) PFOS (Perfluorooctane sulfonate)	
	PFBA (Perfluorobutanoic acid) PFBS (Perfluorobutane sulfonate) PFDA (Perfluorodecanoic acid) PFHxA (Perfluorohexanoic acid) PFNA (Perfluorononanoic acid) PFUnDA (Perfluoroundecanoic acid)
PESTICIDES	
2,4-D (2,4-Dichlorophenoxyacetic acid) Organophosphate metabolites DEDTP (Diethyldithiophosphate) DEP (Diethylphosphate) DETP (Diethylthiophosphate) DMDTP (Dimethyldithiophosphate) DMP (Dimethylphosphate) DMTP (Dimethylthiophosphate Pyrethroid metabolites *cis*-DBCA (*cis*-3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid) *cis*-DCCA (*cis*-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid) *trans*-DCCA (*trans*- 3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid) 4-F-3-PBA (4-Fluoro-3-phenoxybenzoic acid) 3-PBA (3-Phenoxybenzoic acid)	
	Atrazine metabolites AM (Atrazine mercapturate) DEA (Desethylatrazine) DACT (Diaminochlorotriazine) Carbamate metabolites Carbofuranphenol 2-Isopropoxyphenol

continued on the next page

<table>
<tr><th>Cycle 1 (2007–2009)</th><th>Cycle 2 (2009–2011)</th></tr>
<tr><td colspan="2">PHTHALATE METABOLITES</td></tr>
<tr><td colspan="2">MBzP (Mono-benzyl phthalate)
M<i>n</i>BP (Mono-<i>n</i>-butyl phthalate)
MCPP (Mono-3-carboxypropyl phthalate)
MCHP (Mono-cyclohexyl phthalate)
MEHP (Mono-2-ethylhexyl phthalate)
MEHHP (Mono-(2-ethyl-5-hydroxyhexyl) phthalate)
MEOHP (Mono-(2-ethyl-5-oxohexyl) phthalate)
MEP (Mono-ethyl phthalate)
MiNP (Mono-isononyl phthalate)
MMP (Mono-methyl phthalate)
MOP (Mono-<i>n</i>-octyl phthalate)</td></tr>
<tr><td></td><td>MiBP (Mono-isobutyl phthalate)</td></tr>
<tr><td colspan="2">BENZENE METABOLITES</td></tr>
<tr><td></td><td><i>t,t</i>-MA (<i>trans,trans</i>-Muconic acid)
Phenol
<i>S</i>-PMA (S-Phenylmercapturic acid)</td></tr>
<tr><td colspan="2">PAH (POLYCYCLIC AROMATIC HYDROCARBON) METABOLITES</td></tr>
<tr><td></td><td>Benzo[<i>a</i>]pyrene metabolite
  3-Hydroxybenzo[<i>a</i>]pyrene
Chrysene metabolites
  2-Hydroxychrysene
  3-Hydroxychrysene
  4-Hydroxychrysene
  6-Hydroxychrysene
Fluoranthene metabolite
  3-Hydroxyfluoranthene
Fluorene metabolites
  2-Hydroxyfluorene
  3-Hydroxyfluorene
  9-Hydroxyfluorene
Naphthalene metabolites
  1-Hydroxynaphthalene
  2-Hydroxynaphthalene
Phenanthrene metabolites
  1-Hydroxyphenanthrene
  2-Hydroxyphenanthrene
  3-Hydroxyphenanthrene
  4-Hydroxyphenanthrene
  9-Hydroxyphenanthrene
Pyrene metabolite
  1-Hydroxypyrene</td></tr>
</table>

Owing to the high cost of laboratory analyses, some environmental chemicals were not measured for all CHMS participants. Two subsamples were selected for environmental chemicals: one to measure perfluoroalkyl substances in plasma among 12 to 79 year olds and one to measure several environmental chemicals in urine among 3 to 79 year olds (Table 3.4.2). Further details on the subsampling for environmental chemicals are available in *Canada Health Measures Survey (CHMS) Data User Guide: Cycle 2* (Statistics Canada, 2013) and in Giroux et al.'s sampling strategy overview (Giroux et al., 2013).

■ Table 3.4.2
Environmental chemicals measured by age group in cycle 2 (2009–2011) of the Canadian Health Measures Survey.

Measure	Matrix	Target sample size	Age (years)					
			3–5	6–11	12–19	20–39	40–59	60–79
Metals and trace elements	Urine, blood	5,700	■	■	■	■	■	■
Arsenic (speciated)	Urine	2,500	■	■	■	■	■	■
Fluoride	Urine	2,500	■	■	■	■	■	■
Benzene metabolites	Urine	2,500	■	■	■	■	■	■
Chlorophenols	Urine	2,500	■	■	■	■	■	■
Environmental phenols and triclocarban	Urine	2,500	■	■	■	■	■	■
Nicotine metabolite	Urine	5,700	■	■	■	■	■	■
Perfluoroalkyl substances	Plasma	1,500	—	—	■	■	■	■
Atrazine metabolites	Urine	2,500	■	■	■	■	■	■
Carbamate metabolites	Urine	2,500	■	■	■	■	■	■
2,4-D	Urine	2,500	■	■	■	■	■	■
Organophosphate metabolites	Urine	2,500	■	■	■	■	■	■
Pyrethroid metabolites	Urine	2,500	■	■	■	■	■	■
Phthalate metabolites	Urine	2,500	■	■	■	■	■	■
PAH metabolites	Urine	2,500	■	■	■	■	■	■

3.5 ETHICAL CONSIDERATIONS

Personal information collected through the CHMS is protected under the federal *Statistics Act* (Canada, 1970-71-72). Under the Act, Statistics Canada is obliged to safeguard and to keep in trust the information it obtains from the Canadian public. Consequently, Statistics Canada has established a comprehensive framework of policies, procedures, and practices to protect confidential information against loss, theft, unauthorized access, disclosure, copying, or use; this includes physical, organizational, and technological measures. The steps taken by Statistics Canada to safeguard the information collected in the CHMS have been described previously (Day et al., 2007).

Ethics approval for all components of the CHMS was obtained from Health Canada's Research Ethics Board. Informed written consent for the MEC portion of the CHMS was obtained from participants older than 14 years of age. For younger children, a parent or legal guardian provided written consent, and the child provided assent. Participation in this survey was voluntary, and participants could opt out of any part of the survey at any time.

A strategy was developed to communicate results to survey participants with the advice and expert opinion of the CHMS Laboratory Advisory Committee, the Physician Advisory Committee, l'Institut national de santé publique du Québec (the reference laboratory performing the environmental chemical analyses), and Health Canada's Research Ethics Board (Day et al., 2007). For the environmental chemicals, only results for lead, mercury, cadmium, and fluoride were actively reported to participants. However, participants could receive all other test results upon request to Statistics Canada. More information on reporting to participants, including the ethical challenges encountered, can be found in Haines et al. (2011).

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FIELDWORK 4

Fieldwork for the Canadian Health Measures Survey (CHMS) took place over a period of 2.5 years from August 2009 to November 2011. Data were collected sequentially at 18 sites across Canada. The sites were ordered to take into account seasonality by region and the temporal effect, subject to operational and logistical constraints.

Statistics Canada mailed an advance letter and brochure to households that were selected as outlined in section 3.3.2 (Dwelling and Participant Sampling). The mailing informed potential participants that they would be contacted for the survey's data collection.

Data was collected from consenting survey participants through a household personal interview, using a computer-assisted method, and a visit to a mobile examination centre (MEC) for physical measures. The field team consisted of household interviewers and the CHMS MEC staff, including trained health professionals who performed the physical measures testing (Statistics Canada, 2013b).

Participants were first administered a household questionnaire in their home. Using a computer application, the interviewer randomly selected one or two participants and conducted separate 45- to 60-minute health interviews (Statistics Canada, 2013b). The interviews collected demographic and socioeconomic data and information about lifestyle, medical history, current health status, the environment, and housing conditions.

Within approximately 2 weeks after the home visit, participants visited the MEC. Each MEC consisted of two trailers linked by an enclosed pedestrian walkway. One trailer served as a reception containing an administration area and an examination room; the other contained additional examination rooms and a laboratory. The MEC operated 7 days a week in order to complete approximately 350 visits at each site over 5 to 6 weeks and to accommodate participants' schedules (Statistics Canada, 2013b). MEC appointments averaged about 2.5 hours. A parent or legal guardian accompanied children under 14 years of age. To maximize response rates, participants who were unable or unwilling to go to the MEC were offered the option of a home visit by members of the CHMS MEC staff to perform some of the physical measures and the biospecimen collection portion of the survey (Statistics Canada, 2013b).

At the start of the MEC visit, participants signed consent/assent forms prior to any testing and in most cases provided a urine sample immediately thereafter. For logistical purposes, spot samples were collected rather than 24-hour urine samples. The urine samples were collected using the first catch urine, as opposed to the mid-stream urine collected in cycle 1, in order to optimize new infectious disease testing introduced in cycle 2. Also new for cycle 2, guidelines were provided to participants asking them to abstain from urinating 2 hours prior to their MEC visit. Samples were collected in 120 mL urine specimen containers. Trained health professionals took physical health measurements such as height, weight, blood pressure, lung function, and physical fitness. A series of screening questions were administered to determine their eligibility for the various tests, including phlebotomy (blood collection), based on pre-existing exclusion criteria (Statistics Canada, 2013b). Blood specimens were drawn by a certified phlebotomist; the maximum amount depended upon the age of the participant. The approximate volume drawn from participants aged 3–5 years was 22.0 mL; 6–11 years, 28.5 mL; 12–13 years, 48.8 mL; 14–19 years, 52.8 mL; and 20–79 years, 72.8 mL.

All blood and urine specimens collected in the MEC were processed and aliquotted in the MEC. Biospecimens were stored temporarily in two freezers at -20°C until shipping. Once a week, the specimens were shipped on dry ice to the reference laboratory for analyses. Standardized operating procedures were developed for the collection of blood and urine specimens, processing and aliquoting procedures, as well as for shipping biospecimens to ensure adequate data quality and to standardize data collection. A priority sequence for laboratory analyses was established in the event that an insufficient volume of biospecimen was collected for complete analyses of the environmental chemicals as well as for analyses of infectious diseases, nutritional status, and chronic diseases. Details on the collection tubes, aliquot volumes, and priority testing are presented in Table 4.1.

Table 4.1

Urine and blood collection procedure for the environmental chemicals (in order of testing priority) measured in cycle 2 (2009–2011) of the Canadian Health Measures Survey.

Measure	Matrix	Collection Tube (size and type[a])	Aliquot Volume[b]
Metals and trace elements	Whole Blood	4.0 mL Lavender EDTA[c]	1.8 mL
Perfluoroalkyl substances	Plasma	4.0 or 10.0 mL Lavender EDTA[c]	2.4 mL
Environmental phenols and triclocarban, organophosphate metabolites, 2,4-dichlorophenoxyacetic acid (2,4-D), carbamate metabolites, chlorophenols	Urine	120 mL urine specimen container	1.0 mL
Metals and trace elements			1.8 mL
Creatinine and nicotine metabolite			1.0 mL
Phthalate metabolites			4.0 mL
Pyrethroid metabolites			12 mL
Polycyclic aromatic hydrocarbon metabolites, atrazine metabolites, benzene metabolites			20 mL
Arsenic (speciated)			4.0 mL
Fluoride			1.0 mL[d] or 1.8 mL[e]

a Becton Dickinson Vacutainers were used for the collection of blood; VWR urine specimen containers were used for the collection of urine.

b Optimum sample volume sent to the reference laboratory

c EDTA: ethylenediaminetetraacetic acid

d Participants 3–5 years of age

e Participants 6–79 years of age

To maximize the reliability and validity of the data and to reduce systematic bias, the CHMS developed quality assurance and quality control protocols for all aspects of the fieldwork. Quality assurance for the MEC covered staff selection and training, instructions to respondents (pre-testing guidelines), and issues related to data collection. All staff had appropriate education and training for their respective positions. To ensure consistent measurement techniques, procedure manuals and training guides were developed in consultation with, and reviewed by, experts in the field. Quality control samples were done at each site, consisting of three field blanks (deionized water for most analytes) and blind commercial control samples when available for an analyte. These control samples were done on the following chemicals:

- all metals in blood and urine (not including urinary speciated arsenic, blood copper, blood and urinary molybdenum, silver, and uranium);
- organophosphate metabolites;
- chlorophenols (not including 2,4-dichlorophenol and 2,4,5-trichlorophenol);
- pyrethroid metabolites (not including 4-fluoro-3-phenoxybenzoic acid and *cis*-3-(2,2-dibromovinyl) -2,2-dimethylcyclopropane carboxylic acid);
- 1-hydroxypyrene;
- benzene metabolites;
- cotinine; and
- creatinine.

Blind commercial controls were not done for certain chemicals (including phthalates, some PAHs, environmental phenols and triclocarban, 2,4-D, and some metals) because commercial controls were not readily available.

The quality control samples were sent to the laboratory with a regular specimen shipment. Results were sent to Statistics Canada's CHMS headquarters, along with all other respondent results, where they were assessed to determine the accuracy of the methodology based on the defined analyte concentration. If required, feedback was provided quickly to the reference laboratory for review and remedial action.

During the MEC visit a sub-sample of participants were also asked to collect indoor air samples from their households using an indoor air sampler. Participants were asked to place the indoor air sampler in their household for 7 days in order to measure a number of volatile organic contaminants. One indoor air sampler was given per selected household, along with a pencil, postage-paid envelope and information sheet. After the 7 day collection period was over, participants mailed their indoor air sampler in the envelope provided to CASSEN Testing Laboratories where all indoor air analyses were performed.

A complete list of the substances measured in the indoor air samples is available in the *Canadian Health Measures Survey (CHMS) Content Summary for Cycles 1, 2 and 3* (Statistics Canada, 2013a). Further details on the indoor air study are available in the *Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 2* (Statistics Canada, 2013b). Data from the indoor air samplers are available upon request by contacting Statistics Canada at info@statcan.gc.ca.

Detailed descriptions of the CHMS MEC operations and logistics have been described previously in Bryan et al. (2007) and are presented in the *Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 2* (Statistics Canada, 2013b).

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LABORATORY ANALYSES 5

Laboratory analyses of environmental chemicals and creatinine were performed at the Centre de toxicologie du Québec of l'Institut national de santé publique du Québec (INSPQ), city of Québec. INSPQ followed standardized operating procedures that were developed for every assay and technique performed in its laboratory. The laboratory, which is accredited under ISO 17025, used numerous internal and external quality control programs. The limit of detection for each method is presented in Appendix B.

Internal quality control measures within INSPQ included the use of calibration standards, laboratory blanks, and other in-house reference materials. External quality control measures included participation in inter-laboratory comparison studies for most analytes. Quality assurance reviews were conducted on laboratory data in order to identify inconsistencies in results, such as assay drifting.

The methods used in the analyses of the environmental chemicals and creatinine are described below.

5.1 METALS AND TRACE ELEMENTS

5.1.1 Blood Analyses

Blood samples were diluted in a basic solution containing octylphenol ethoxylate and ammonia. They were analyzed for cadmium, cobalt, copper, lead, manganese, molybdenum, total mercury, nickel, selenium, silver, uranium, and zinc by inductively coupled plasma-mass spectrometry (ICP-MS) (Perkin Elmer Sciex, Elan DRC II). Matrix matched calibration was performed using blood from a non-exposed individual (INSPQ, 2009a).

5.1.2 Urine Analyses

Urine samples were diluted in 0.5% nitric acid and analyzed for antimony, total arsenic, cadmium, cesium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, silver, thallium, tungsten, uranium, vanadium, and zinc by ICP-MS (Perkin Elmer Sciex, Elan DRC II). Matrix matched calibration was performed using urine from non-exposed individuals (INSPQ, 2009b).

5.1.2.1 Arsenic (speciated)

Urine samples were diluted in ammonium carbonate and analyzed for arsenite (+3 oxidation state), arsenate (+5 oxidation state), monomethylarsonic acid, dimethylarsinic acid, and arsenocholine and arsenobetaine combined using ultra performance liquid chromatography (UPLC) on a Waters Acquity UPLC (Galaxie software) coupled to ICP-MS on a Varian 820-MS (Varian ICP-MS Expert software package version 2.1) (INSPQ, 2009c).

5.1.2.2 Fluoride

Fluoride in urine samples were analyzed using Orion pH meter with fluoride ion selective electrode (Orion Research Inc.) (INSPQ, 2009).

5.2 BENZENE METABOLITES

Benzene metabolites (*trans,trans*-muconic acid and *S*-phenylmercapturic acid) were extracted from urine by hydrophilic-lipophilic-balanced solid-phase extraction using the automated Janus workstation. The extracts were evaporated to dryness, reconstituted in the mobile phase, and analyzed using UPLC on a Waters Acquity UPLC coupled to tandem mass spectrometry on a Waters Quattro Premier XE (MassLynx software) in the multiple reaction monitoring (MRM) mode operated in negative ion mode (INSPQ, 2009e).

Urinary phenol was hydrolyzed in β-glucuronidase enzyme and again in mild acid. The samples were then derivatized with pentafluorobenzyl bromide at 80°C for 2 hours. The derivatized products were extracted with a mixture of dichloromethane-hexane. Evaporated extracts were redissolved and analyzed by gas chromatography on an Agilent 6890 or 7890 coupled to tandem mass spectrometry on a Waters Quattro Premier XE (MassLynx software) operating in MRM mode following negative ion chemical ionization (INSPQ, 2009f).

5.3 CHLOROPHENOLS

Urinary chlorophenols (2,4-dichlorophenol, 2,5-dichlorophenol, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, and pentachlorophenol) were hydrolyzed in β-glucuronidase enzyme and again in mild acid. The samples were then derivatized with pentafluorobenzyl bromide at 80°C for 2 hours. The derivatized products were extracted with a mixture of dichloromethane-hexane. Evaporated extracts were redissolved and analyzed by gas chromatography on an Agilent 6890 or 7890 coupled to tandem mass spectrometry on a Waters Quattro Premier XE (MassLynx software) operating in MRM mode following negative ion chemical ionization (INSPQ, 2009f).

5.4 ENVIRONMENTAL PHENOLS AND TRICLOCARBAN

Urinary bisphenol A, triclocarban, and triclosan were hydrolyzed in β-glucuronidase enzyme and again in mild acid. The samples were then derivatized with pentafluorobenzyl bromide at 80°C for 2 hours. The derivatized products were extracted with a mixture of dichloromethane-hexane. Evaporated extracts were redissolved and analyzed by gas chromatography on an Agilent 6890 or 7890 coupled to tandem mass spectrometry on a Waters Quattro Premier XE (MassLynx software) operating in MRM mode following negative ion chemical ionization (INSPQ, 2009f). Free and hydrolyzed forms of bisphenol A were measured together by this procedure.

5.5 NICOTINE METABOLITE

Cotinine was recovered from urine samples by solid-phase extraction using an automated Janus workstation. Deuterated cotinine was used as the internal standard. The extract was then redissolved in the mobile phase, and analyzed using UPLC on a Waters Acquity UPLC coupled to tandem mass spectrometry on a Waters Quattro Premier XE (MassLynx software) in MRM mode with an ion source in positive ion mode (INSPQ, 2009g).

5.6 PERFLUOROALKYL SUBSTANCES

Perfluoroctane sulfonate, perfluorooctanoic acid, perfluorohexane sulfonate, perfluorononanoic acid, perfluorobutanoic acid, perfluorobutane sulfonate, perfluorohexanoic acid, perfluorodecanoic acid, and perfluoroundecanoic acid were extracted from plasma samples with methyl-tert butyl ether after forming an ion pair with tetrabutylammonium hydrogensulfate. Extracts were evaporated to dryness and dissolved in 200 μL of the mobile phase. They were analyzed by UPLC on a Waters Acquity UPLC coupled to tandem mass spectrometry on a Waters Quattro Premier XE (MassLynx software) in MRM mode with an electrospray ion source in the negative ion mode (INSPQ, 2009h).

5.7 PESTICIDES

5.7.1 Atrazine Metabolites

Atrazine metabolites (diaminochlorotriazine, desethylatrazine, and atrazine mercapturate) in urine were extracted using a strong anion exchange solid-phase extraction column with the automated Janus workstation. The extracts were evaporated to dryness and reconstituted in the mobile phase and analyzed by UPLC on a Waters Acquity UPLC coupled to tandem mass spectrometry on a Waters Quattro Premier XE (MassLynx software) in MRM mode following electrospray ionization in the positive ion mode (INSPQ, 2009i).

5.7.2 Carbamate Metabolites, 2,4-Dichlorophenoxyacetic Acid, and Organophosphate Metabolites

Urinary carbamate metabolites (carbofuranphenol and 2-isopropoxyphenol), 2,4-dichlorophenoxyacetic acid, and organophosphate metabolites (diethyl phosphate, dimethyl phosphate, diethyl thiophosphate, dimethyl thiophosphate, diethyl dithiophosphate, and dimethyl dithiophosphate) were hydrolyzed in β-glucuronidase enzyme and again in mild acid. The samples were then derivatized with pentafluorobenzyl bromide at 80°C for 2 hours. The derivatized products were extracted with a mixture of dichloromethane-hexane. Evaporated extracts were redissolved and analyzed by gas chromatography on an Agilent 6890 or 7890 coupled to tandem mass spectrometry on a Waters Quattro Micro-GC (MassLynx software) operating in MRM mode following negative ion chemical ionization (INSPQ, 2009f).

5.7.3 Pyrethroid Metabolites

Urinary pyrethroid metabolites (4-fluoro-3-phenoxybenzoic acid; *cis*-3-(2,2-dibromovinyl)-2, 2-dimethylcyclopropane-1-carboxylic acid; *cis*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid; *trans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid; 3-phenoxybenzoic acid) were hydrolyzed in β-glucuronidase enzyme. The samples were then acidified and extracted with hexane. Extracts were derivatized and extracted a second time with a mixture of isooctane-hexane. Evaporated extracts were dissolved in hexane and analyzed by gas chromatography on an Agilent 6890 N coupled to mass spectrometry on an Agilent 5973 N operated in the single ion monitoring mode following negative chemical ionization (Agilent MSD Chem software) (INSPQ, 2009j).

5.8 PHTHALATE METABOLITES

Urine samples were spiked with the internal standard solution and phthalate metabolites (mono-benzyl phthalate, mono-butyl phthalate, mono-3-carboxypropyl phthalate, mono-cyclohexyl phthalate, mono-2-ethylhexyl phthalate, mono-(2-ethyl-5-hydroxyhexyl) phthalate, mono-(2-ethyl-5-oxohexyl) phthalate, mono-ethyl phthalate, mono-isobutyl phthalate, mono-isononyl phthalate, mono-methyl phthalate, and mono-*n*-octyl phthalate) were hydrolyzed at 37°C for 90 minutes with β-glucuronidase enzymatic solution in an ammonium acetate buffer at a pH of 6.5. The samples were acidified with phosphoric acid and extracted using strong anion-exchange solid-phase extraction columns using an automated Janus workstation. Phthalate metabolites were eluted using 2% formic acid in acetonitrile solution, evaporated to dryness, reconstituted in deionized water and analyzed by UPLC on a Waters Acquity UPLC coupled to tandem mass spectrometry on a Waters Quattro Premier XE (MassLynx software) in MRM mode following electrospray ionization in negative ion mode (Waters Acquity UPLC, Waters Quattro Premier XE, MassLynx software) (INSPQ, 2009k).

During the course of the phthalate analyses for cycle 1, INSPQ identified accuracy issues with the commercial "certified" standard solutions that were used to develop calibration curves (Langlois et al., 2012). All relevant data from cycle 1 have been adjusted using compound-specific correction factors derived from the accuracy investigation. Information regarding the development of the compound-specific correction factors will be presented in a future publication.

5.9 POLYCYCLIC AROMATIC HYDROCARBON METABOLITES

Polycyclic aromatic hydrocarbon metabolites (3-hydroxybenzo[*a*]pyrene, 2-hydroxychrysene, 3-hydroxychrysene, 4-hydroxychrysene, 6-hydroxychrysene, 3-hydroxyfluoranthene, 2-hydroxyfluorene, 3-hydroxyfluorene, 9-hydroxyfluorene, 1-hydroxynaphthalene, 2-hydroxynaphthalene, 1-hydroxyphenanthrene, 2-hydroxyphenanthrene, 3-hydroxyphenanthrene, 4-hydroxyphenanthrene, 9-hydroxyphenanthrene, and 1-hydroxypyrene) in urine samples were hydrolyzed using β-glucuronidase enzymatic solution and extracted with an organic solvent at neutral pH. The extracts were evaporated and derivatized with *N*-methyl-*N*-(trimethylsilyl)-trifluoroacetamide and analyzed using gas chromatography on an Agilent 7890 coupled to mass spectrometry on an Agilent 7000B triple-quad tandem mass spectrometry operated in MRM mode with an ion source in electron ionization mode (Agilent MassHunter software) (INSPQ, 2011).

5.10 CREATININE

Creatinine was measured in urine using the colorimetric end-point Jaffe method. An alkaline solution of sodium picrate reacts with creatinine in urine to form a red Janovski complex using Microgenics DRI Creatinine-Detect reagents (#917). The absorbance was read at 505 nm on a Hitachi 917 chemistry autoanalyzer (INSPQ, 2008).

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STATISTICAL DATA ANALYSES

6

Descriptive statistics on the concentrations of environmental chemicals in blood and urine of Canadians, aged 3 to 79 years, were generated using the Statistical Analysis System software (SAS Institute Inc., version 9.2, 2008) and the SUDAAN® (SUDAAN Release 10.0, 2008) statistical software package.

The Canadian Health Measures Survey (CHMS) is a sample survey, meaning that the participants represent many other Canadians not included in the survey. In order for the results of the survey to be representative of the entire population, sample weights were generated by Statistics Canada and incorporated into all estimates presented in this report (e.g. geometric means). Survey weights were used to take into account the unequal probability of selection into the survey as well as non-response. Further, to account for the complex survey design of the CHMS, the set of bootstrap weights included with the data set was used to estimate the 95% confidence intervals (CIs) for all means and percentiles (Rao et al., 1992; Rust & Rao, 1996).

For each chemical measured in cycle 2, data tables are presented. Data from cycle 1 are also provided within the tables for those substances measured in both cycles. In the first *Report on Biomonitoring of Environmental Chemicals in Canada* all results were reported to two decimal places. For cycle 2 of the CHMS, the reporting protocol changed and the results were reported to two significant digits. For consistency, cycle 1 data was adjusted to two significant digits prior to generating the descriptive statistics and data from both cycles is presented to two significant digits. Therefore, the descriptive statistics presented in this report for cycle 1 may differ from those presented in the first report. The differences are not significant and the values presented in the first report are still considered to be accurate.

The data tables include the sample size (n); percentage of results that fall below the limit of detection (LOD); geometric mean (GM); the 10th, 50th, 75th, and 95th percentiles; and associated 95% CIs. Three steps were involved in the calculation of the GM and associated 95% CIs. First, the log of each variable was calculated. Second, the mean and 95% CIs for the log transformed variables were calculated using bootstrap weights. Finally, the GM and associated 95% CIs were calculated by taking the antilog of the log transformed mean and associated 95% CIs. For each chemical, results are presented for the total population as well as by age group and sex (except for 3-5 year olds). For each chemical that was measured in both cycle 1 and cycle 2 of the CHMS, a summary table is provided that compares results for the aggregate of all age groups common to both cycles and for that same aggregate population separated by sex. Measurements that fell below the LOD for the laboratory analytical method were assigned a value equal to half the LOD. If the proportion of results below the LOD was greater than 40%, GMs were not calculated. Percentile estimates that are less than the LOD are reported as <LOD. Appendix B contains a table of LOD values for each chemical, specific to each cycle. A table of conversion factors is provided in Appendix C to assist in the comparison of data from other studies that report different units.

Chemicals measured in either whole blood or plasma are presented as weight of chemical per volume of whole blood or plasma (e.g. µg chemical/L blood or plasma).

For urine measurements, concentrations are presented as weight of chemical per volume of urine (e.g. µg chemical/L urine) and adjusted for urinary creatinine (e.g. µg chemical/g creatinine). Urinary creatinine is a chemical by-product generated from muscle metabolism; it is frequently used to adjust for urine concentration (or dilution) in spot urine samples because its production and excretion are relatively constant over 24 hours owing to homeostatic controls (Barr et al., 2005; Boeniger et al., 1993; Pearson et al., 2009). If the chemical measured behaves similarly to creatinine in the kidney, it will be filtered at the same rate, thus expressing the chemical per gram of creatinine helps adjust for the effect of urinary dilution as well as some differences in renal function and lean body mass (Barr et al., 2005; CDC, 2009; Pearson et al., 2009). Creatinine is primarily excreted by glomerular filtration; therefore, creatinine adjustment may not be appropriate for compounds that are excreted primarily by tubular secretion in the kidney (Barr et al., 2005; Teass et al., 2003). In addition, creatinine excretion can vary due to age, sex and ethnicity; therefore, it may not be appropriate to compare creatinine-adjusted concentrations between different demographic groups (e.g. children with adults) (Barr et al., 2005). Where urinary creatinine values were missing or <LOD, the estimate of that participant's creatinine-adjusted chemical was not calculated and was also set to missing.

Descriptive statistics are presented for creatinine (mg/dL) in Appendix D. These include *n*; % <LOD; GM; the 10th, 50th, 75th, and 95th percentiles; and associated 95% CIs for the total population as well as by age group and gender. Measurements that fell below the LOD for the laboratory analytical method were assigned a value equal to half the LOD.

Specific gravity was also measured in all urine samples at the mobile examination centre, immediately following sample collection. Urinary specific gravity is the ratio of densities between urine and pure water and can be used to adjust for variations in urine output, similar to urinary creatinine adjustment. Urinary specific gravity adjustment has not been done for any of the chemicals presented in this report; however, specific gravity data are available upon request by contacting Statistics Canada at info@statcan.gc.ca should they wish to perform this adjustment for their own data analyses.

Under the *Statistics Act*, Statistics Canada is required to ensure participant confidentiality. Therefore, estimates based on a small number of participants are suppressed. Following suppression rules for the CHMS, any estimate based on fewer than 10 participants is suppressed in this report. To avoid suppression, estimates at the 95th percentile require at least 200 participants, estimates at the 10th percentile require at least 100 participants, estimates at the 75th percentile require at least 40 participants, estimates at the 50th percentile require at least 20 participants, and estimates of the geometric mean require at least 10 participants.

Estimates from a sample survey inevitably include sampling errors. Measuring the possible scope of sampling errors is based on the standard error of the estimates drawn from the survey results. To get a better indication of the size of the standard error, it is often more useful to express the standard error in terms of the estimate being measured. The resulting measure, called the coefficient of variation (CV), is obtained by dividing the standard error of the estimate by the estimate itself, and it is expressed as a percentage of the estimate (Statistics Canada, 2013). Statistics Canada employs the following guidelines for releasing estimates based on their CV, which have been followed in this report:

- When a CV is between 16.6% and 33.3%, an estimate can be considered for general unrestricted release but is accompanied by a warning cautioning subsequent users of the high sampling variability associated with the estimate. These estimates are identified by the superscript letter E.
- When a CV is greater than 33.3%, Statistics Canada recommends not releasing the estimate because conclusions based on these data will be unreliable and most likely invalid. These estimates will not be published and will instead be replaced by the letter F.

Further details on the sample weights and data analysis are available in the *Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 2* (Statistics Canada, 2013).

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CONSIDERATIONS FOR INTERPRETING THE BIOMONITORING DATA

7

The Canadian Health Measures Survey (CHMS) was designed to provide estimates of environmental chemical concentrations in blood or urine for the Canadian population as a whole. The first cycle of the survey covered approximately 96.3% of the Canadian population aged 6 to 79 years. The second cycle included children as young as 3 years of age and covered approximately 96.3% of the Canadian population up to 79 years of age. The survey was not designed to permit breakdown of data by collection site. In addition, the CHMS design did not target specific exposure scenarios; consequently, it did not select or exclude participants on the basis of their potential for low or high exposures to environmental chemicals.

Biomonitoring can estimate how much of a chemical is present in a person, but it cannot say what health effects, if any, may result from that exposure. The ability to measure environmental chemicals at very low concentrations has advanced in recent years. However, the presence alone of a chemical in a person's body does not necessarily mean that it will cause a health effect. Factors such as the dose, the toxicity of the chemical, and the duration and timing of exposure are important to determine whether potential adverse health effects may occur. For chemicals such as lead or mercury, research studies have provided a good understanding of the health risks associated with different concentrations in blood. However, for many chemicals, further research is needed to understand the potential health effects, if any, from different blood or urine concentrations. Furthermore, small amounts of certain chemicals, such as manganese and zinc, are essential for the maintenance of good health and would be expected to be present in the body. In addition, the way in which a chemical will act in the body will differ among individuals and cannot be predicted with certainty. Certain populations (children, pregnant women, the elderly or immuno-compromised people) may be more susceptible to the effects of exposure.

The absence of a chemical does not necessarily mean a person has not been exposed. It may be that the technology is not capable of detecting such a small amount, or that the exposure occurred at an earlier point in time allowing for the chemical to be eliminated from the person's body before measurement took place.

Biomonitoring cannot tell us the source or route of the exposure. The amount of chemical measured indicates the total amount that has entered the body through all routes of exposure (ingestion, inhalation, and skin contact) and from all sources (air, water, soil, food, and consumer products). The detection of the chemical may be the result of exposure to a single source or multiple sources. In addition, in most cases biomonitoring cannot distinguish between natural and anthropogenic sources. Many chemicals (lead, mercury, cadmium, and arsenic) occur naturally in the environment and are also present in human-made products.

Metals are the only chemicals measured in urine as the parent compounds. Almost all other chemicals are measured as metabolites. For many chemicals, parent compounds may be broken down (i.e. metabolized) in the body into one or more metabolites. For example, the pyrethroid insecticide cyfluthrin is broken down into several metabolites. Some metabolites are specific to one parent compound whereas others are common to several parent compounds. Several urinary metabolites are also formed in the environment (e.g. dialkyl phosphate metabolites). Their presence in urine does not necessarily mean that an exposure to the parent chemical has occurred; rather, exposure could be to the metabolite itself in media such as food, water, or air.

Factors that contribute to the concentrations of chemicals measured in blood and urine include the quantity entering the body through all routes of exposure, absorption rates, distribution to various tissues in the body, metabolism, and excretion of the chemical and/or its metabolites from the body. These processes depend on both the characteristics of the chemical, including its solubility in fat (or lipophilicity), its pH, its particle size, and the characteristics of the individual being exposed, such as age, diet, health status, and race. For these reasons, the way in which a chemical will act in the body will differ among individuals and cannot be predicted with certainty.

This report includes temporal data for substances measured in both cycle 1 (2007–2009) and cycle 2 (2009–2011) and baseline data for substances introduced to the survey in cycle 2. Results from future cycles of CHMS can be compared with the baseline data from cycle 1 and cycle 2 in order to begin to examine trends in Canadians' exposures to selected environmental chemicals. It is important to note that there were some sampling and analytical modifications between cycles that may have contributed some variation in results for those substances measured in both cycle 1 and cycle 2. The limits of detection (LOD) for certain analytical methods changed from cycle 1 to cycle 2. Although the LOD values did not change by a large margin, this difference should be noted when comparing data from cycles 1 and 2. A list of LOD values from cycles 1 and 2 is provided in Appendix B. In addition, the urine collection protocol and guidelines were changed in cycle 2, and this may have resulted in a shift in creatinine levels when cycle 1 and cycle 2 are compared. This, in turn, could affect creatinine-adjusted levels of some chemicals.

Urinary creatinine concentrations can also be affected by variables such as age, sex and ethnicity resulting in differences among demographic groups within a single cycle (Mage et al., 2004). In particular, creatinine excretion per unit bodyweight increases substantially with increasing age in children (Aylward et al., 2011; Remer et al., 2002). As a result, it is acceptable to compare creatinine-adjusted concentrations among similar demographic groups (e.g. children with children, adults with adults) but not among two different demographic groups (e.g. children with adults) (Barr et al., 2005).

More in-depth statistical analyses of the CHMS biomonitoring data, including time trends, exploring relationships among environmental chemicals, other physical measures, and self-reported information are beyond the scope of this report, and may be performed in the future. The CHMS data are being made available to scientists upon request by contacting Statistics Canada at info@statcan.gc.ca and will be a resource for additional scientific analysis.

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METAL AND TRACE ELEMENT SUMMARIES AND RESULTS

8

8.1 ANTIMONY

Antimony (CASRN 7440-36-0) is a naturally occurring element present in the Earth's crust at an average concentration of approximately 0.00002% (Emsley, 2001). It is classified as a metalloid, exhibiting both metallic and non-metallic characteristics. It can exist as a pure metal as well as in various oxidation states and forms (ATSDR, 1992). The trivalent (+3) form is the most stable and is commonly found in antimony compounds including antimony trioxide and antimony trisulphide (ATSDR, 1992).

Antimony is released naturally into the environment as a result of weathering of rocks, runoff from soils, emissions from volcanic eruptions, sea spray, and forest fires (Health Canada, 1997). Primary anthropogenic releases of antimony occur through industrial processes. Antimony may enter surface water by way of effluents from mining and manufacturing operations, as well as through industrial and municipal leachate discharges. Atmospheric releases are the result of stack dust outputs from industrial sources such as coal-fired power plants, inorganic chemical plants, and metal smelters (Health Canada, 1997).

Antimony is used in the production of semi-conductors, and infrared detectors and diodes, and as an additive in paint pigments, glass, and ceramic products (Health Canada, 1997; NTP, 2005). It is also used as a component in alloys for batteries, cable sheathing, plumbing solder, ammunition and fireworks, and flame retardant and anti-friction materials (ATSDR, 1992; Health Canada, 1997; NTP, 2005). Some forms of antimony are used in pharmaceutical products or to induce vomiting following poisonings (WHO, 2003).

Canadians are exposed to antimony mainly through ingestion of food, but also to some extent from water, air (including tobacco smoke), dust, or direct dermal contact with consumer products containing antimony (Environment Canada & Health Canada, 2010). The absorption, distribution and excretion of antimony depend on both the route of administration and its oxidation state. The available data suggest an average intestinal absorption of less than 10% (ATSDR, 1992). Following ingestion in animals, the liver, kidney, bone, lung, spleen, and thyroid are the major sites of accumulation outside the gastrointestinal tract (Health Canada, 1997). After inhalation, tissue distribution studies show that the trivalent form accumulates more rapidly in the liver than the pentavalent form, whereas pentavalent antimony is found preferentially in the skeleton. Clearance and retention of antimony depend mainly on solubility (NTP, 2005). Inhaled antimony trioxide is retained in the lung with long half-lives for lung clearance (Garg et al., 2003). Once absorbed, antimony is relatively rapidly cleared from other tissues with an estimated elimination half-life of 3 to 4 days (Kentner et al., 1995). In humans, urine is the primary route of excretion with pentavalent antimony tending to be more readily excreted in the urine than the trivalent form (Elinder & Friberg, 1986; Health Canada, 1997). Antimony is most commonly measured in blood and urine, and this measurement is reflective of exposure to antimony and antimony-related compounds, such as antimony trioxide (ATSDR, 1992).

The levels of antimony to which the general population is exposed are not expected to cause any adverse health effects (ATSDR, 1992). Acute oral and inhalation exposure to high doses of antimony may cause gastrointestinal effects in humans whereas chronic exposure to low doses of antimony compounds is primarily associated with myocardial effects (Health Canada, 1997). The International Agency for Research on Cancer has classified antimony trioxide as Group 2B, a possible human carcinogen, and antimony trisulphide as Group 3, not classifiable as to its carcinogenicity to humans (IARC, 1989).

As part of the Chemicals Management Plan under the *Canadian Environmental Protection Act, 1999,* antimony trioxide was identified as a high-priority substance and a final screening assessment was published in September 2010 (Canada, 1999; Canada, 2011a; Environment Canada & Health Canada, 2010). The assessment concluded that antimony trioxide is not of concern to the environment or to human health at current levels of exposure (Environment Canada & Health Canada, 2010). Antimony and its compounds are included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011). The leachable antimony content in a variety of consumer products is regulated under the *Canada Consumer Product Safety Act* (Canada, 2010a). These regulated consumer products include paints and other surface coatings on cribs, toys, and other products for use by a child in learning or play situations (Canada, 2010b; Canada, 2011b).

Considering both toxicity and analytical capabilities, a Canadian drinking water quality guideline has been developed that sets out the maximum acceptable concentration of antimony (Health Canada, 1997). Currently, there are no guidelines for antimony trioxide in drinking water in Canada because of insufficient data for its presence in drinking water (Environment Canada & Health Canada, 2010).

In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric mean of antimony in whole blood was 5.40 µg/L (INSPQ, 2004). Urinary antimony concentrations were less than the detection limit of 0.12 µg/L in over 50% of the participants (INSPQ, 2004).

Antimony was measured in the urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented as both µg/L (Tables 8.1.1, 8.1.2, and 8.1.3) and µg/g creatinine (Tables 8.1.4, 8.1.5, and 8.1.6). Finding a measurable amount of antimony in urine is an indicator of exposure to antimony or antimony-containing compounds and does not necessarily mean that an adverse health effect will occur.

Table 8.1.1

Antimony — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5492	22.40	0.042 (0.040 - 0.045)	<LOD	0.043 (0.040 - 0.045)	0.079 (0.074 - 0.083)	0.18 (0.17 - 0.19)
Total, 6–79	2	5738	19.90	0.048 (0.046 - 0.050)	<LOD	0.045 (0.043 - 0.048)	0.087 (0.081 - 0.092)	0.19 (0.16 - 0.22)
Males, Total 6–79	1	2662	15.63	0.051 (0.048 - 0.054)	<LOD	0.051 (0.047 - 0.055)	0.092 (0.084 - 0.099)	0.19 (0.17 - 0.22)
Males, Total 6–79	2	2746	15.51	0.054 (0.051 - 0.058)	<LOD	0.052 (0.047 - 0.057)	0.098 (0.089 - 0.11)	0.23[E] (0.14 - 0.31)
Females, Total 6–79	1	2830	28.76	0.035 (0.032 - 0.038)	<LOD	0.035 (0.032 - 0.039)	0.068 (0.064 - 0.071)	0.16 (0.14 - 0.19)
Females, Total 6–79	2	2992	23.93	0.042 (0.040 - 0.045)	<LOD	0.039 (0.035 - 0.042)	0.077 (0.069 - 0.086)	0.16 (0.14 - 0.18)

[a] For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.1.2

Antimony — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6311	20.00	0.048 (0.046 - 0.050)	<LOD	0.045 (0.043 - 0.048)	0.087 (0.081 - 0.092)	0.19 (0.16 - 0.22)
3–5[b]	1							
3–5	2	573	20.94	0.052 (0.046 - 0.059)	<LOD	0.051 (0.040 - 0.063)	0.087 (0.073 - 0.10)	0.18 (0.12 - 0.24)
6–11	1	1034	17.99	0.048 (0.044 - 0.054)	<LOD	0.051 (0.047 - 0.055)	0.084 (0.076 - 0.091)	0.18 (0.14 - 0.21)
6–11	2	1062	13.56	0.057 (0.051 - 0.063)	<LOD	0.056 (0.049 - 0.064)	0.090 (0.078 - 0.10)	0.18 (0.13 - 0.23)
12–19	1	983	12.92	0.059 (0.053 - 0.065)	<LOD	0.065 (0.058 - 0.073)	0.098 (0.090 - 0.11)	0.19 (0.16 - 0.23)
12–19	2	1041	14.22	0.061 (0.054 - 0.069)	<LOD	0.066 (0.059 - 0.072)	0.10 (0.092 - 0.11)	0.20 (0.17 - 0.24)
20–39	1	1169	25.66	0.042 (0.038 - 0.047)	<LOD	0.043 (0.038 - 0.048)	0.081 (0.074 - 0.089)	0.19 (0.15 - 0.23)
20–39	2	1321	21.73	0.050 (0.045 - 0.056)	<LOD	0.046 (0.042 - 0.051)	0.089 (0.079 - 0.10)	0.20[E] (0.083 - 0.31)
40–59	1	1223	27.80	0.040 (0.037 - 0.042)	<LOD	0.040 (0.037 - 0.043)	0.074 (0.070 - 0.078)	0.18 (0.15 - 0.20)
40–59	2	1228	23.62	0.045 (0.041 - 0.049)	<LOD	0.041 (0.034 - 0.049)	0.082 (0.074 - 0.091)	0.22 (0.18 - 0.25)
60–79	1	1083	25.58	0.036 (0.034 - 0.038)	<LOD	0.035 (0.033 - 0.038)	0.066 (0.060 - 0.072)	0.14 (0.11 - 0.16)
60–79	2	1086	25.14	0.040 (0.037 - 0.044)	<LOD	0.037 (0.034 - 0.040)	0.073 (0.065 - 0.081)	0.16 (0.13 - 0.19)

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[b] Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.1.3

Antimony — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	15.55	0.055 (0.051 - 0.058)	<LOD	0.052 (0.047 - 0.057)	0.097 (0.089 - 0.11)	0.23 (0.15 - 0.30)
Males, 6–11	1	524	14.12	0.052 (0.043 - 0.063)	<LOD	0.053 (0.046 - 0.060)	0.088 (0.073 - 0.10)	0.18 (0.13 - 0.23)
Males, 6–11	2	532	11.65	0.056 (0.048 - 0.065)	<LOD[E] (<LOD - 0.022)	0.054 (0.044 - 0.064)	0.080 (0.063 - 0.098)	0.17[E] (0.079 - 0.25)
Males, 12–19	1	505	8.51	0.065 (0.058 - 0.074)	0.021[E] (<LOD - 0.029)	0.068 (0.059 - 0.078)	0.099 (0.089 - 0.11)	0.20 (0.14 - 0.27)
Males, 12–19	2	542	11.81	0.068 (0.058 - 0.079)	F	0.071 (0.057 - 0.085)	0.11 (0.089 - 0.14)	0.21 (0.14 - 0.29)
Males, 20–39	1	514	18.68	0.049 (0.042 - 0.057)	<LOD	0.051 (0.041 - 0.060)	0.093 (0.079 - 0.11)	0.19 (0.14 - 0.24)
Males, 20–39	2	551	16.15	0.059 (0.051 - 0.068)	<LOD	0.056 (0.045 - 0.067)	0.10 (0.083 - 0.13)	0.33[E] (0.14 - 0.52)
Males, 40–59	1	578	18.34	0.051 (0.047 - 0.055)	<LOD	0.048 (0.044 - 0.053)	0.094 (0.083 - 0.11)	0.20 (0.15 - 0.26)
Males, 40–59	2	616	16.88	0.052 (0.045 - 0.061)	<LOD	0.050 (0.040 - 0.059)	0.097 (0.079 - 0.11)	0.24[E] (0.15 - 0.34)
Males, 60–79	1	541	17.93	0.046 (0.041 - 0.051)	<LOD	0.045 (0.039 - 0.051)	0.079 (0.070 - 0.088)	0.16 (0.12 - 0.20)
Males, 60–79	2	505	21.19	0.045 (0.040 - 0.050)	<LOD	0.042 (0.038 - 0.046)	0.088 (0.076 - 0.10)	0.16 (0.13 - 0.18)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	24.12	0.042 (0.040 - 0.045)	<LOD	0.039 (0.036 - 0.042)	0.077 (0.069 - 0.085)	0.16 (0.14 - 0.19)
Females, 6–11	1	510	21.96	0.045 (0.041 - 0.049)	<LOD	0.049 (0.044 - 0.054)	0.079 (0.072 - 0.086)	0.17 (0.13 - 0.21)
Females, 6–11	2	530	15.47	0.057 (0.052 - 0.064)	<LOD	0.060 (0.050 - 0.069)	0.095 (0.080 - 0.11)	0.19[E] (0.12 - 0.25)
Females, 12–19	1	478	17.57	0.052 (0.047 - 0.058)	<LOD	0.059 (0.051 - 0.067)	0.094 (0.077 - 0.11)	0.19 (0.15 - 0.24)
Females, 12–19	2	499	16.83	0.055 (0.047 - 0.063)	<LOD	0.064 (0.055 - 0.073)	0.094 (0.088 - 0.10)	0.18 (0.15 - 0.20)
Females, 20–39	1	655	31.15	0.037 (0.033 - 0.041)	<LOD	0.036 (0.031 - 0.042)	0.071 (0.063 - 0.080)	0.18[E] (0.11 - 0.25)
Females, 20–39	2	770	25.71	0.043 (0.038 - 0.049)	<LOD	0.041 (0.035 - 0.046)	0.081 (0.064 - 0.097)	0.15 (0.12 - 0.18)
Females, 40–59	1	645	36.28	0.031 (0.027 - 0.036)	<LOD	0.030 (0.024 - 0.035)	0.058 (0.049 - 0.067)	0.15 (0.13 - 0.17)
Females, 40–59	2	612	30.39	0.039 (0.035 - 0.043)	<LOD	0.034 (0.029 - 0.038)	0.068 (0.051 - 0.085)	0.16 (0.12 - 0.20)
Females, 60–79	1	542	33.21	0.029 (0.026 - 0.032)	<LOD	0.028 (0.024 - 0.031)	0.049 (0.042 - 0.056)	0.12 (0.098 - 0.14)
Females, 60–79	2	581	28.57	0.036 (0.032 - 0.041)	<LOD	0.033 (0.028 - 0.038)	0.064 (0.051 - 0.078)	0.16 (0.11 - 0.22)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.1.4

Antimony (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5479	22.45	0.053 (0.051 - 0.056)	<LOD	0.050 (0.048 - 0.053)	0.074 (0.070 - 0.078)	0.16 (0.14 - 0.18)
Total, 6–79	2	5719	19.97	0.045 (0.042 - 0.047)	<LOD	0.043 (0.041 - 0.045)	0.067 (0.064 - 0.070)	0.15 (0.13 - 0.18)
Males, Total 6–79	1	2653	15.68	0.052 (0.049 - 0.055)	<LOD	0.049 (0.046 - 0.052)	0.074 (0.068 - 0.079)	0.15 (0.12 - 0.19)
Males, Total 6–79	2	2739	15.55	0.043 (0.041 - 0.046)	<LOD	0.042 (0.038 - 0.045)	0.065 (0.062 - 0.069)	0.15 (0.12 - 0.18)
Females, Total 6–79	1	2826	28.80	0.055 (0.052 - 0.059)	<LOD	0.052 (0.049 - 0.055)	0.075 (0.069 - 0.080)	0.16 (0.13 - 0.19)
Females, Total 6–79	2	2980	24.03	0.046 (0.043 - 0.050)	<LOD	0.044 (0.042 - 0.047)	0.068 (0.062 - 0.075)	0.16 (0.13 - 0.20)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.1.5

Antimony (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6291	20.06	0.046 (0.043 - 0.048)	<LOD	0.044 (0.042 - 0.046)	0.069 (0.065 - 0.073)	0.16 (0.14 - 0.19)
3–5[b]	1							
3–5	2	572	20.98	0.089 (0.079 - 0.10)	<LOD	0.085 (0.073 - 0.097)	0.13 (0.12 - 0.14)	0.32^{E} (0.18 - 0.47)
6–11	1	1031	18.04	0.077 (0.072 - 0.082)	<LOD	0.074 (0.069 - 0.078)	0.10 (0.095 - 0.11)	0.21 (0.16 - 0.27)
6–11	2	1058	13.61	0.064 (0.058 - 0.071)	<LOD	0.060 (0.053 - 0.067)	0.090 (0.079 - 0.10)	0.19^{E} (0.12 - 0.26)
12–19	1	982	12.93	0.052 (0.049 - 0.056)	<LOD	0.049 (0.045 - 0.053)	0.070 (0.064 - 0.075)	0.12 (0.094 - 0.14)
12–19	2	1039	14.24	0.045 (0.042 - 0.050)	<LOD	0.045 (0.042 - 0.048)	0.066 (0.060 - 0.073)	0.12 (0.094 - 0.14)
20–39	1	1165	25.75	0.050 (0.046 - 0.054)	<LOD	0.047 (0.045 - 0.049)	0.070 (0.064 - 0.076)	0.16 (0.13 - 0.20)
20–39	2	1319	21.76	0.041 (0.038 - 0.046)	<LOD	0.039 (0.037 - 0.040)	0.061 (0.055 - 0.068)	0.16^{E} (0.088 - 0.24)
40–59	1	1218	27.91	0.054 (0.050 - 0.057)	<LOD	0.051 (0.048 - 0.054)	0.073 (0.067 - 0.079)	0.16 (0.14 - 0.19)
40–59	2	1223	23.71	0.043 (0.040 - 0.046)	<LOD	0.042 (0.040 - 0.045)	0.065 (0.059 - 0.070)	0.15 (0.12 - 0.18)
60–79	1	1083	25.58	0.053 (0.050 - 0.056)	<LOD	0.050 (0.047 - 0.053)	0.074 (0.070 - 0.079)	0.14 (0.12 - 0.16)
60–79	2	1080	25.28	0.047 (0.044 - 0.051)	<LOD	0.047 (0.044 - 0.050)	0.071 (0.064 - 0.077)	0.16 (0.13 - 0.18)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.1.6

Antimony (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	15.59	0.044 (0.042 - 0.047)	<LOD	0.043 (0.040 - 0.046)	0.067 (0.063 - 0.071)	0.15 (0.11 - 0.19)
Males, 6–11	1	522	14.18	0.081 (0.075 - 0.087)	<LOD	0.077 (0.071 - 0.083)	0.11 (0.096 - 0.11)	0.23[E] (0.11 - 0.36)
Males, 6–11	2	530	11.70	0.061 (0.052 - 0.071)	<LOD (<LOD - 0.039)	0.059 (0.051 - 0.067)	0.085 (0.072 - 0.099)	0.15[E] (0.092 - 0.21)
Males, 12–19	1	504	8.53	0.056 (0.052 - 0.060)	0.030 (<LOD - 0.033)	0.055 (0.051 - 0.060)	0.073 (0.068 - 0.079)	0.12 (0.096 - 0.14)
Males, 12–19	2	541	11.83	0.046 (0.040 - 0.052)	<LOD (<LOD - 0.029)	0.045 (0.040 - 0.050)	0.068 (0.057 - 0.079)	0.13 (0.099 - 0.17)
Males, 20–39	1	512	18.75	0.046 (0.042 - 0.052)	<LOD	0.041 (0.035 - 0.048)	0.066 (0.056 - 0.076)	0.16 (0.12 - 0.21)
Males, 20–39	2	550	16.18	0.041 (0.035 - 0.048)	<LOD	0.037 (0.032 - 0.042)	0.063 (0.051 - 0.074)	0.16[E] (0.067 - 0.25)
Males, 40–59	1	574	18.47	0.052 (0.048 - 0.055)	<LOD	0.051 (0.046 - 0.055)	0.072 (0.065 - 0.079)	0.16 (0.11 - 0.21)
Males, 40–59	2	615	16.91	0.042 (0.038 - 0.045)	<LOD	0.039 (0.035 - 0.044)	0.063 (0.055 - 0.071)	0.15 (0.13 - 0.17)
Males, 60–79	1	541	17.93	0.050 (0.046 - 0.054)	<LOD	0.046 (0.042 - 0.050)	0.066 (0.060 - 0.072)	0.14 (0.11 - 0.16)
Males, 60–79	2	503	21.27	0.043 (0.041 - 0.047)	<LOD	0.045 (0.041 - 0.049)	0.065 (0.060 - 0.069)	0.13 (0.096 - 0.17)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	24.21	0.047 (0.043 - 0.051)	<LOD	0.045 (0.042 - 0.048)	0.071 (0.064 - 0.077)	0.17 (0.13 - 0.20)
Females, 6–11	1	509	22.00	0.073 (0.067 - 0.078)	<LOD	0.070 (0.065 - 0.075)	0.098 (0.088 - 0.11)	0.19 (0.14 - 0.23)
Females, 6–11	2	528	15.53	0.068 (0.061 - 0.075)	<LOD	0.061 (0.054 - 0.069)	0.098 (0.081 - 0.12)	0.24[E] (0.13 - 0.35)
Females, 12–19	1	478	17.57	0.049 (0.044 - 0.053)	<LOD	0.045 (0.042 - 0.049)	0.063 (0.052 - 0.074)	0.12[E] (0.047 - 0.19)
Females, 12–19	2	498	16.87	0.045 (0.042 - 0.048)	<LOD	0.045 (0.040 - 0.049)	0.065 (0.060 - 0.070)	0.11 (0.090 - 0.12)
Females, 20–39	1	653	31.24	0.053 (0.049 - 0.058)	<LOD	0.050 (0.047 - 0.053)	0.071 (0.066 - 0.075)	0.16[E] (0.088 - 0.24)
Females, 20–39	2	769	25.75	0.042 (0.037 - 0.048)	<LOD	0.039 (0.036 - 0.043)	0.060 (0.049 - 0.071)	0.16[E] (0.082 - 0.24)
Females, 40–59	1	644	36.34	0.055 (0.049 - 0.062)	<LOD	0.051 (0.045 - 0.057)	0.074 (0.063 - 0.084)	0.17 (0.13 - 0.20)
Females, 40–59	2	608	30.59	0.045 (0.040 - 0.050)	<LOD	0.044 (0.041 - 0.047)	0.066 (0.056 - 0.076)	0.16[E] (0.092 - 0.24)
Females, 60–79	1	542	33.21	0.056 (0.052 - 0.060)	<LOD	0.056 (0.051 - 0.060)	0.079 (0.067 - 0.090)	0.14 (0.12 - 0.17)
Females, 60–79	2	577	28.77	0.051 (0.046 - 0.057)	<LOD	0.049 (0.043 - 0.055)	0.078 (0.067 - 0.089)	0.17 (0.14 - 0.20)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

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8.2 ARSENIC

Arsenic (CASRN 7440-38-2) is a naturally occurring element making up a small fraction (0.00015%) of the Earth's crust (ATSDR, 2007; Emsley, 2001). It is classified as a metalloid, exhibiting properties of both a metal and a non-metal. Arsenic is commonly found as an inorganic sulphide complexed with other metals (CCME, 1997). Arsenic also forms stable organic compounds in its trivalent (+3) and pentavalent (+5) states. Common organic arsenic compounds include monomethylarsonic acid (MMA), dimethylarsinic acid (DMA), arsenobetaine, and arsenocholine (WHO, 2001).

Arsenic may enter lakes, rivers, or groundwater naturally through erosion and weathering of soils, minerals, and ores (Health Canada, 2006). The primary anthropogenic sources of arsenic are the smelting of metal ores, the use of arsenical pesticides, and the burning of fossil fuels (WHO, 2001). In Canada, smelting of gold ores is the primary anthropogenic source of arsenic (Environment Canada & Health Canada, 1993).

Arsenic is used in the manufacture of transistors, lasers and semi-conductors, and in the processing of glass, pigments, textiles, paper, metal adhesives, ceramics, wood preservatives, ammunition, and explosives. Historical uses of arsenic include application of lead arsenate as a pesticide in apple orchards and vineyards and arsenic trioxide as a herbicide (ATSDR, 2007; Health Canada, 2006). Chromated copper arsenate was formerly used as a wood preservative in residential construction projects, such as playground structures and decks; however, it is now used only for industrial purposes and for domestic wood foundations (Health Canada, 2005). Organic arsenical herbicides, such as MMA and DMA, are no longer registered for use in Canada (Environment Canada, 2008; EPA, 2006; Health Canada, 2012).

The public can be exposed to arsenic through food, drinking water, soil, and ambient air (Environment Canada & Health Canada, 1993). Food is the major source of intake with total arsenic concentrations being highest in seafood (IARC, 2012). Inorganic arsenic is the predominant form found in meats, dairy products, and cereal; organic arsenic, including arsenobetaine and arsenocholine, predominates in seafood, fruit, and vegetables (CDC, 2009; IARC, 2012). Exposure may also arise from indoor house dust; levels in dust can exceed levels in soil (Rasmussen et al., 2001). Further, exposure to arsenic may be elevated in populations residing in areas where industrial or natural sources occur.

Inorganic arsenic is readily absorbed, up to 95%, in the gastrointestinal tract; however, absorption may be much lower for highly insoluble forms of arsenic (ATSDR, 2007). Following oral ingestion, inorganic arsenic appears rapidly in blood circulation where it binds primarily to hemoglobin. Within 24 hours, it is found mainly in the liver, kidney, lung, spleen, and skin. Skin, bone, and muscle represent the major storage sites. In cases of chronic exposure, arsenic will preferentially accumulate in tissues rich in keratin or sulfhydryl functional groups, such as hair, nails, skin, and other protein-containing tissues (Human Biomonitoring Commission, 2003). Metabolism of inorganic arsenic involves an initial reduction of pentavalent to trivalent arsenic followed by oxidative methylation to monomethylated, dimethylated, and trimethylated products including MMA and DMA (WHO, 2011). Methylation facilitates the excretion of inorganic arsenic from the body because the end-products MMA and DMA are readily excreted in urine (WHO, 2001). Arsenobetaine and other organic forms of arsenic found in seafood are readily and rapidly absorbed from the gastrointestinal tract, do not undergo significant metabolism, and are predominantly and rapidly eliminated in urine (WHO, 2001).

Biomarkers of arsenic exposure include the levels of arsenic or its metabolites in blood, hair, nails, and urine (WHO, 2001). Measurements of speciated metabolites in urine expressed either as inorganic arsenic or as the sum of metabolites (inorganic arsenic + MMA + DMA) are generally accepted as the most reliable indicator of recent arsenic exposure (ATSDR, 2007; WHO, 2001). Measurements of arsenic in urine have been used to identify recent arsenic ingestion or above-average exposures in populations living near industrial point sources of arsenic (ATSDR, 2007). Blood arsenic levels are not as well correlated with drinking water concentrations and speciation of the chemical forms of arsenic in blood is difficult (Valentine et al., 1979; WHO, 2001).

Chronic ingestion of drinking water contaminated with inorganic arsenic has been associated with decreased lung function, non-cancer skin effects, and cardiovascular effects including increased incidence of high blood pressure and circulatory problems (ATSDR, 2007; Environment Canada & Health Canada, 1993). In addition, increased incidences of skin cancer and various cancers of the internal organs have been associated with chronic ingestion of inorganic arsenic-contaminated drinking water (Health Canada, 2006). Much of the evidence comes from an epidemiological study conducted in southwestern Taiwan (Chen et al., 1985; Health Canada, 2006; Tseng, 1977; Wu et al., 1989). Arsenic and inorganic arsenic compounds are classified as carcinogenic to humans by Health Canada and other international agencies (EPA, 1998; Health Canada, 2006; IARC, 2012).

Although the majority of assessments on the toxicity of arsenic have concentrated on the inorganic forms, recent studies have highlighted the potential for organic arsenic compounds, in particular the pentavalent DMA, to exert carcinogenic effects (Cohen et al., 2006; IARC, 2012; Schwerdtle et al., 2003). The International Agency for Research on Cancer (IARC) has classified the methylated arsenic metabolites MMA and DMA as Group 2B, possibly carcinogenic to humans (IARC, 2012). IARC has also evaluated arsenobetaine and other organic arsenic compounds and found them to be not classifiable as to their carcinogenicity to humans (Group 3) (IARC, 2012).

Health Canada and Environment Canada concluded that arsenic in Canada may be harmful to the environment and may constitute a danger to human life or health (Environment Canada & Health Canada, 1993). Inorganic arsenic compounds are listed on Schedule 1, List of Toxic Substances, under the *Canadian Environmental Protection Act, 1999* (CEPA 1999). The Act allows the federal government to control the importation, manufacture, distribution, and use of inorganic arsenic compounds in Canada (Canada, 1999; Canada, 2000). Risk management actions under CEPA 1999 have been developed to control releases of arsenic from thermal electric power generation, base-metal smelting, wood preservation, and steel manufacturing processes (Environment Canada, 2010). Arsenic and its compounds are included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011). The *Food and Drug Regulations* prohibit the sale in Canada of drugs for human use containing arsenic or any of its salts or derivatives (Canada, 2012). Further, the leachable arsenic content in a variety of consumer products is regulated under the *Canada Consumer Product Safety Act* (Canada, 2010a). These regulated consumer products include paints and other surface coatings on cribs, toys, and other products for use by a child in learning or play situations (Canada, 2010b; Canada, 2011).

Health Canada has developed a Canadian drinking water quality guideline that sets out the maximum acceptable concentration of arsenic (Health Canada, 2006). The guideline was developed based on the incidence of internal (lung, bladder, and liver) cancers in humans and the ability of currently available treatment technologies to remove arsenic from drinking water (Health Canada, 2006). Arsenic is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply. The concentration of arsenic in some foods is regulated by Health Canada under the *Food and Drug Regulations*; current food tolerances are in the process of being updated (Canada, 2012).

In a study carried out in British Columbia to assess the levels of trace elements in 61 non-smoking adults aged 30 to 65 years, the geometric mean concentration and 95th percentile of total arsenic in urine were 27.8 µg/g creatinine and 175.5 µg/g creatinine, respectively (Clark et al., 2007). In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric mean of total arsenic in urine was 12.73 µg/L and in whole blood was 0.95 µg/L (INSPQ, 2004).

Total arsenic was measured in the urine of all Canadian Health Measures Survey (CHMS) participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented as both µg/L (Tables 8.2.1.1, 8.2.1.2, and 8.2.1.3) and µg/g creatinine (Tables 8.2.1.4, 8.2.1.5, and 8.2.1.6).

8.2.1 Arsenic (total)

Table 8.2.1.1

Arsenic (total) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5492	0.18	12 (9.8 - 14)	3.1 (2.8 - 3.4)	11 (8.7 - 13)	23 (18 - 28)	67 (48 - 86)
Total, 6–79	2	5738	1.93	9.2 (7.7 - 11)	2.0 (1.7 - 2.4)	7.9 (6.7 - 9.0)	20 (15 - 24)	77 (58 - 96)
Males, Total 6–79	1	2662	0.23	13 (11 - 16)	3.6 (3.2 - 4.0)	12 (8.8 - 15)	25 (18 - 32)	70 (47 - 92)
Males, Total 6–79	2	2746	1.71	10 (8.3 - 12)	2.1 (1.8 - 2.5)	9.0 (7.4 - 11)	22 (15 - 28)	80^{E} (48 - 110)
Females, Total 6–79	1	2830	0.14	11 (9.0 - 12)	2.7 (2.2 - 3.2)	10 (8.6 - 12)	21 (17 - 25)	65 (47 - 84)
Females, Total 6–79	2	2992	2.14	8.3 (7.0 - 9.9)	2.0 (1.4 - 2.6)	7.2 (6.2 - 8.2)	18 (13 - 22)	74 (56 - 91)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.1.2

Arsenic (total) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6311	1.96	9.1 (7.7 - 11)	2.0 (1.7 - 2.3)	7.8 (6.7 - 8.9)	19 (15 - 24)	76 (58 - 94)
3–5[b]	1							
3–5	2	573	2.27	6.6 (5.1 - 8.4)	F	6.3 (4.7 - 8.0)	11 (7.8 - 14)	41 (31 - 51)
6–11	1	1034	0.10	9.5 (8.0 - 11)	2.4 (1.8 - 3.0)	9.5 (7.9 - 11)	18 (14 - 22)	51^{E} (29 - 73)
6–11	2	1062	2.26	7.0 (6.3 - 7.8)	2.0 (1.5 - 2.4)	6.8 (6.3 - 7.3)	13 (11 - 14)	44^{E} (26 - 62)
12–19	1	983	0.31	11 (9.1 - 14)	3.3 (2.2 - 4.3)	11 (8.6 - 13)	20 (14 - 26)	54 (35 - 73)
12–19	2	1041	2.21	7.2 (5.8 - 8.9)	1.9^{E} (1.1 - 2.7)	6.4 (5.3 - 7.4)	14 (10 - 17)	52^{E} (17 - 88)
20–39	1	1169	0.09	12 (10 - 14)	3.0 (2.5 - 3.4)	11 (9.5 - 13)	25 (17 - 32)	66 (47 - 85)
20–39	2	1321	2.12	9.6 (8.0 - 11)	2.1 (1.7 - 2.5)	8.4 (6.9 - 9.9)	20 (15 - 26)	74 (63 - 85)
40–59	1	1223	0.41	12 (10 - 15)	3.1 (2.6 - 3.6)	11 (8.4 - 15)	24 (19 - 30)	72^{E} (42 - 100)
40–59	2	1228	1.55	9.3 (7.3 - 12)	2.1^{E} (1.1 - 3.0)	8.1 (6.5 - 9.8)	20 (15 - 26)	70 (50 - 91)
60–79	1	1083	0	12 (9.2 - 15)	3.5 (2.9 - 4.1)	11 (6.9 - 14)	22 (17 - 28)	72 (49 - 96)
60–79	2	1086	1.57	11 (7.8 - 15)	2.1 (1.4 - 2.7)	9.2 (6.3 - 12)	25^{E} (12 - 38)	120^{E} (44 - 190)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.2.1.3

Arsenic (total) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	1.71	9.9 (8.3 - 12)	2.1 (1.8 - 2.4)	8.9 (7.4 - 10)	21 (15 - 28)	80^{E} (50 - 110)
Males, 6–11	1	524	0.19	9.4 (6.9 - 13)	2.4^{E} (1.3 - 3.6)	9.5 (7.4 - 12)	17 (11 - 23)	51^{E} (31 - 70)
Males, 6–11	2	532	2.07	7.1 (6.1 - 8.2)	2.1 (1.6 - 2.7)	6.8 (6.2 - 7.5)	12 (9.6 - 15)	39^{E} (18 - 61)
Males, 12–19	1	505	0.40	11 (8.8 - 14)	3.6 (2.8 - 4.4)	10 (7.9 - 12)	19 (14 - 24)	F
Males, 12–19	2	542	2.21	7.1 (5.7 - 8.8)	2.0 (1.4 - 2.6)	6.1 (5.2 - 7.0)	12 (8.0 - 17)	F
Males, 20–39	1	514	0.19	13 (11 - 15)	3.5 (2.9 - 4.2)	12 (9.1 - 15)	27 (18 - 37)	65 (47 - 84)
Males, 20–39	2	551	2.18	11 (8.4 - 14)	2.1 (1.5 - 2.8)	9.6 (6.8 - 12)	24^{E} (14 - 34)	81^{E} (32 - 130)
Males, 40–59	1	578	0.35	15 (11 - 18)	4.0 (2.8 - 5.2)	14 (9.1 - 18)	29 (21 - 36)	79^{E} (27 - 130)
Males, 40–59	2	616	0.65	11 (8.5 - 15)	2.0^{E} (0.78 - 3.3)	10 (7.9 - 13)	26^{E} (15 - 37)	80^{E} (41 - 120)
Males, 60–79	1	541	0	14 (10 - 18)	3.8 (2.8 - 4.8)	13 (8.6 - 18)	25 (19 - 32)	75^{E} (45 - 100)
Males, 60–79	2	505	1.58	11 (8.3 - 15)	2.4 (1.9 - 2.9)	10 (7.3 - 13)	24^{E} (15 - 33)	110 (80 - 140)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	2.20	8.3 (7.0 - 9.8)	2.0 (1.4 - 2.6)	7.2 (6.2 - 8.1)	17 (13 - 22)	74 (56 - 91)
Females, 6–11	1	510	0	9.6 (8.1 - 11)	2.2 (1.4 - 2.9)	9.5 (7.4 - 12)	20 (16 - 23)	F
Females, 6–11	2	530	2.45	6.9 (5.9 - 8.0)	1.4^{E} (0.80 - 2.0)	6.7 (5.9 - 7.4)	13 (10 - 16)	F
Females, 12–19	1	478	0.21	11 (8.6 - 15)	2.7^{E} (0.75 - 4.7)	11 (8.4 - 14)	22^{E} (13 - 30)	54 (35 - 73)
Females, 12–19	2	499	2.20	7.3 (5.6 - 9.4)	F	6.6 (5.4 - 7.9)	14 (9.6 - 18)	F
Females, 20–39	1	655	0	11 (9.4 - 13)	2.4 (1.7 - 3.0)	11 (9.6 - 12)	22 (17 - 27)	66^{E} (36 - 97)
Females, 20–39	2	770	2.08	8.7 (7.2 - 10)	2.0^{E} (1.2 - 2.9)	7.4 (6.2 - 8.6)	17 (13 - 22)	73 (52 - 94)
Females, 40–59	1	645	0.47	10 (8.6 - 12)	2.8 (2.2 - 3.4)	9.6 (7.7 - 12)	22 (18 - 26)	66^{E} (42 - 91)
Females, 40–59	2	612	2.45	7.8 (6.0 - 9.9)	2.1^{E} (1.0 - 3.1)	7.0 (5.7 - 8.2)	16 (11 - 22)	58^{E} (34 - 81)
Females, 60–79	1	542	0	10 (8.0 - 13)	3.2 (2.3 - 4.1)	9.3 (6.4 - 12)	20 (15 - 25)	70 (46 - 95)
Females, 60–79	2	581	1.55	10^{E} (7.2 - 15)	1.5^{E} (<LOD - 2.4)	7.8 (5.0 - 11)	27^{E} (9.0 - 45)	F

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.2.1.4

Arsenic (total) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5479	0.18	14 (11 - 18)	4.7 (3.9 - 5.5)	13 (9.6 - 16)	24 (18 - 30)	67 (45 - 89)
Total, 6–79	2	5719	1.94	8.6 (7.2 - 10)	2.4 (2.1 - 2.8)	7.1 (6.0 - 8.2)	17 (12 - 21)	71 (55 - 87)
Males, Total 6–79	1	2653	0.23	13 (10 - 16)	4.4 (3.6 - 5.2)	11 (8.3 - 13)	22 (17 - 26)	59 (41 - 78)
Males, Total 6–79	2	2739	1.72	8.0 (6.7 - 9.6)	2.3 (1.9 - 2.6)	6.8 (5.6 - 8.0)	15 (11 - 19)	66 (46 - 86)
Females, Total 6–79	1	2826	0.14	16 (13 - 20)	5.0 (4.1 - 5.9)	14 (11 - 17)	27 (19 - 35)	78 (53 - 100)
Females, Total 6–79	2	2980	2.15	9.2 (7.6 - 11)	2.6 (2.2 - 3.1)	7.3 (6.2 - 8.5)	18 (13 - 23)	78 (52 - 100)

[a] For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.1.5

Arsenic (total) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6291	1.97	8.6 (7.3 - 10)	2.5 (2.1 - 2.8)	7.2 (6.1 - 8.3)	17 (13 - 21)	71 (56 - 87)
3–5[b]	1							
3–5	2	572	2.27	11 (8.8 - 14)	3.9[E] (<LOD - 5.3)	9.6 (8.4 - 11)	17 (15 - 19)	F
6–11	1	1031	0.10	15 (12 - 18)	5.3 (4.5 - 6.1)	13 (9.4 - 16)	24 (19 - 29)	59[E] (17 - 100)
6–11	2	1058	2.27	7.9 (7.1 - 8.8)	2.9 (2.6 - 3.2)	6.6 (6.1 - 7.1)	13 (10 - 16)	54[E] (27 - 80)
12–19	1	982	0.31	9.8 (7.6 - 13)	3.7 (3.1 - 4.3)	9.1 (7.0 - 11)	16 (11 - 20)	36[E] (21 - 51)
12–19	2	1039	2.21	5.3 (4.5 - 6.3)	1.9 (1.5 - 2.3)	4.5 (3.6 - 5.3)	8.1 (6.7 - 9.5)	39[E] (16 - 61)
20–39	1	1165	0.09	13 (11 - 16)	4.5 (3.8 - 5.3)	12 (9.0 - 15)	23 (17 - 29)	60 (39 - 80)
20–39	2	1319	2.12	7.9 (6.6 - 9.4)	2.3 (1.9 - 2.7)	6.6 (5.1 - 8.0)	15 (12 - 19)	56 (42 - 70)
40–59	1	1218	0.41	16 (12 - 20)	5.1 (3.7 - 6.5)	14 (10 - 17)	25 (20 - 30)	F
40–59	2	1223	1.55	8.9 (7.2 - 11)	2.5 (1.9 - 3.1)	7.6 (6.1 - 9.1)	19 (12 - 25)	71 (52 - 89)
60–79	1	1083	0	16 (12 - 22)	5.3 (4.3 - 6.3)	14 (9.2 - 20)	29[E] (17 - 42)	87 (58 - 110)
60–79	2	1080	1.57	13 (9.4 - 17)	3.3 (2.6 - 4.1)	10 (7.2 - 13)	27[E] (15 - 39)	130[E] (37 - 220)

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[b] Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

[E] Use data with caution.

[F] Data is too unreliable to be published.

Table 8.2.1.6

Arsenic (total) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	1.72	8.1 (6.8 - 9.6)	2.3 (1.9 - 2.6)	7.0 (5.8 - 8.1)	15 (11 - 19)	66 (47 - 85)
Males, 6–11	1	522	0.19	14 (11 - 18)	5.4 (4.5 - 6.3)	12 (7.9 - 16)	23 (16 - 29)	F
Males, 6–11	2	530	2.08	7.7 (6.8 - 8.8)	2.9 (2.4 - 3.4)	6.4 (5.7 - 7.2)	13 (9.8 - 16)	49[E] (26 - 72)
Males, 12–19	1	504	0.40	9.4 (7.1 - 12)	3.4 (2.6 - 4.3)	8.9 (7.0 - 11)	15 (10 - 20)	35[E] (20 - 50)
Males, 12–19	2	541	2.22	4.8 (4.0 - 5.7)	1.7 (1.3 - 2.1)	4.1 (3.4 - 4.8)	7.5 (6.4 - 8.6)	37[E] (14 - 60)
Males, 20–39	1	512	0.20	12 (9.4 - 15)	4.1 (2.9 - 5.2)	10 (7.9 - 13)	21 (15 - 27)	48 (39 - 58)
Males, 20–39	2	550	2.18	7.3 (5.8 - 9.2)	2.2 (1.8 - 2.6)	6.6 (4.6 - 8.6)	14 (9.9 - 18)	52[E] (32 - 72)
Males, 40–59	1	574	0.35	14 (11 - 18)	4.6 (3.3 - 6.0)	12 (8.7 - 15)	23 (18 - 29)	F
Males, 40–59	2	615	0.65	8.9 (7.1 - 11)	2.5 (1.9 - 3.1)	7.7 (5.8 - 9.7)	18[E] (9.4 - 27)	74 (48 - 100)
Males, 60–79	1	541	0	14 (11 - 19)	5.1 (4.2 - 6.0)	12 (8.2 - 17)	23 (16 - 30)	73[E] (44 - 100)
Males, 60–79	2	503	1.59	11 (8.1 - 14)	3.0 (2.1 - 3.9)	8.8 (6.1 - 11)	22[E] (12 - 32)	79 (57 - 100)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	2.21	9.3 (7.7 - 11)	2.6 (2.2 - 3.1)	7.4 (6.3 - 8.6)	18 (14 - 23)	78 (53 - 100)
Females, 6–11	1	509	0	15 (13 - 18)	5.3 (4.1 - 6.5)	13 (10 - 16)	25 (19 - 31)	F
Females, 6–11	2	528	2.46	8.1 (6.9 - 9.5)	3.0 (2.5 - 3.4)	6.9 (6.3 - 7.4)	13 (9.1 - 17)	67[E] (25 - 110)
Females, 12–19	1	478	0.21	10 (7.9 - 13)	4.0 (3.3 - 4.8)	9.4 (6.7 - 12)	16 (11 - 21)	39[E] (24 - 54)
Females, 12–19	2	498	2.21	6.0 (4.9 - 7.4)	2.2 (<LOD - 2.7)	5.0 (3.5 - 6.5)	9.0 (5.9 - 12)	40[E] (12 - 68)
Females, 20–39	1	653	0	15 (12 - 19)	4.8 (4.0 - 5.6)	14 (11 - 17)	26 (18 - 35)	79[E] (42 - 120)
Females, 20–39	2	769	2.08	8.4 (7.2 - 9.9)	2.5 (2.0 - 3.1)	6.6 (5.2 - 7.9)	16 (11 - 21)	76[E] (46 - 110)
Females, 40–59	1	644	0.47	17 (14 - 22)	5.6 (3.7 - 7.5)	15 (11 - 20)	27 (21 - 33)	85[E] (37 - 130)
Females, 40–59	2	608	2.47	8.9 (6.9 - 12)	2.5 (1.7 - 3.4)	7.5 (6.0 - 9.1)	19 (13 - 24)	71[E] (40 - 100)
Females, 60–79	1	542	0	19 (14 - 26)	5.7 (4.1 - 7.4)	17[E] (9.5 - 24)	37[E] (23 - 50)	95[E] (57 - 130)
Females, 60–79	2	577	1.56	15 (11 - 20)	3.6 (<LOD - 4.6)	11 (7.6 - 14)	32[E] (15 - 49)	F

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Arsenite (+3), arsenate (+5), and methylated metabolites of arsenic (MMA and DMA) were measured individually in the urine of all CHMS cycle 2 (2009–2011) participants aged 3 to 79 years. The data are presented as both µg/L and µg/g creatinine (Tables 8.2.2.1 to 8.2.5.4).

8.2.2 Arsenite

Table 8.2.2.1

Arsenite — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2537	75.60	—	<LOD	<LOD	1.2[E] (<LOD - 1.8)	4.5[E] (2.2 - 6.7)
3–5	2	516	84.50	—	<LOD	<LOD	<LOD	2.3[E] (1.3 - 3.2)
6–11	2	511	78.86	—	<LOD	<LOD	<LOD	3.0[E] (1.8 - 4.1)
12–19	2	510	72.35	—	<LOD	<LOD	1.3[E] (<LOD - 1.9)	5.2[E] (1.5 - 8.9)
20–39	2	355	69.86	—	<LOD	<LOD	1.4[E] (<LOD - 2.2)	F
40–59	2	356	70.51	—	<LOD	<LOD	F	3.4[E] (1.8 - 4.9)
60–79	2	289	73.01	—	<LOD	<LOD	F	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.2.2.2

Arsenite — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1271	72.54	—	<LOD	<LOD	1.4[E] (<LOD - 1.9)	4.8[E] (1.6 - 8.0)
Males, 6–11	2	260	76.92	—	<LOD	<LOD	<LOD	3.4[E] (1.8 - 5.1)
Males, 12–19	2	255	70.98	—	<LOD	<LOD	1.3[E] (<LOD - 2.1)	5.1[E] (2.0 - 8.2)
Males, 20–39	2	167	62.87	—	<LOD	<LOD	F	x
Males, 40–59	2	193	63.21	—	<LOD	<LOD	1.5[E] (<LOD - 2.1)	x
Males, 60–79	2	141	69.50	—	<LOD	<LOD	F	x
Females, Total 3–79	2	1266	78.67	—	<LOD	<LOD	<LOD	4.0[E] (1.8 - 6.2)
Females, 6–11	2	251	80.88	—	<LOD	<LOD	<LOD	2.8[E] (1.6 - 4.0)
Females, 12–19	2	255	73.73	—	<LOD	<LOD	1.3[E] (<LOD - 2.1)	F
Females, 20–39	2	188	76.06	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	163	79.14	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	148	76.35	—	<LOD	<LOD	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 8.2.2.3

Arsenite (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2527	75.90	—	<LOD	<LOD	1.6 (<LOD - 1.9)	4.5^{E} (2.7 - 6.2)
3–5	2	515	84.66	—	<LOD	<LOD	<LOD	4.7^{E} (3.0 - 6.4)
6–11	2	509	79.17	—	<LOD	<LOD	<LOD	3.8^{E} (2.2 - 5.3)
12–19	2	508	72.64	—	<LOD	<LOD	1.1 (<LOD - 1.4)	4.4^{E} (2.1 - 6.6)
20–39	2	353	70.25	—	<LOD	<LOD	1.5^{E} (<LOD - 2.1)	4.3^{E} (<LOD - 7.1)
40–59	2	354	70.90	—	<LOD	<LOD	<LOD (<LOD - 2.1)	3.9 (2.8 - 5.0)
60–79	2	288	73.26	—	<LOD	<LOD	1.9^{E} (<LOD - 3.0)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.2.2.4

Arsenite (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1267	72.77	—	<LOD	<LOD	1.5 (<LOD - 1.7)	3.7^{E} (1.4 - 6.0)
Males, 6–11	2	259	77.22	—	<LOD	<LOD	<LOD	3.7 (2.5 - 5.0)
Males, 12–19	2	254	71.26	—	<LOD	<LOD	1.0^{E} (<LOD - 1.4)	F
Males, 20–39	2	166	63.25	—	<LOD	<LOD	1.3^{E} (<LOD - 1.9)	x
Males, 40–59	2	193	63.21	—	<LOD	<LOD	1.7 (<LOD - 2.1)	x
Males, 60–79	2	141	69.50	—	<LOD	<LOD	1.5 (<LOD - 1.9)	x
Females, Total 3–79	2	1260	79.05	—	<LOD	<LOD	<LOD	5.0 (3.3 - 6.6)
Females, 6–11	2	250	81.20	—	<LOD	<LOD	<LOD	4.0^{E} (1.7 - 6.2)
Females, 12–19	2	254	74.02	—	<LOD	<LOD	1.4 (<LOD - 1.8)	4.9^{E} (<LOD - 7.5)
Females, 20–39	2	187	76.47	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	161	80.12	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	147	76.87	—	<LOD	<LOD	<LOD (<LOD - 4.3)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

8.2.3 Arsenate

Table 8.2.3.1

Arsenate — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2538	99.49	—	<LOD	<LOD	<LOD	<LOD
3–5	2	516	98.84	—	<LOD	<LOD	<LOD	<LOD
6–11	2	511	99.61	—	<LOD	<LOD	<LOD	<LOD
12–19	2	510	99.41	—	<LOD	<LOD	<LOD	<LOD
20–39	2	355	99.44	—	<LOD	<LOD	<LOD	<LOD
40–59	2	357	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	289	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.3.2

Arsenate — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1271	99.37	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	260	99.23	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	99.22	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	167	98.80	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	141	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1267	99.61	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	251	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	255	99.61	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	188	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	164	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	148	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 8.2.3.3

Arsenate (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2528	99.88	—	<LOD	<LOD	<LOD	<LOD
3–5	2	515	99.03	—	<LOD	<LOD	<LOD	<LOD
6–11	2	509	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	508	99.80	—	<LOD	<LOD	<LOD	<LOD
20–39	2	353	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	355	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	288	100	—	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.2.3.4

Arsenate (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1267	99.68	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	259	99.61	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	99.61	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	166	99.40	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	141	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1261	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	250	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	187	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	162	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	147	100	—	<LOD	<LOD	<LOD	x

[a] Breakdown by sex for the 3–5 year old age group is not recommended.

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

8.2.4 Monomethylarsonic Acid (MMA)

■ Table 8.2.4.1

Monomethylarsonic acid (MMA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD^a	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2538	73.01	—	<LOD	<LOD	1.4^E (<LOD - 1.9)	3.0 (2.3 - 3.7)
3–5	2	516	77.91	—	<LOD	<LOD	<LOD	2.5 (2.1 - 2.9)
6–11	2	511	76.52	—	<LOD	<LOD	<LOD^E (<LOD - 1.3)	3.0 (2.1 - 3.9)
12–19	2	510	62.94	—	<LOD	<LOD	1.7 (1.1 - 2.2)	3.2 (2.2 - 4.2)
20–39	2	355	70.14	—	<LOD	<LOD	1.7 (1.3 - 2.1)	3.3^E (1.8 - 4.7)
40–59	2	357	71.43	—	<LOD	<LOD	1.3^E (<LOD - 1.8)	2.7 (1.7 - 3.6)
60–79	2	289	81.31	—	<LOD	<LOD	<LOD	2.6^E (1.4 - 3.8)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

■ Table 8.2.4.2

Monomethylarsonic acid (MMA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group^a, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD^a	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1271	69.63	—	<LOD	<LOD	1.5 (1.2 - 1.9)	3.4 (2.4 - 4.4)
Males, 6–11	2	260	80.77	—	<LOD	<LOD	<LOD	3.4^E (1.7 - 5.0)
Males, 12–19	2	255	58.82	—	<LOD	<LOD	1.6 (1.1 - 2.2)	3.3^E (2.0 - 4.6)
Males, 20–39	2	167	61.68	—	<LOD	<LOD	2.0 (1.6 - 2.3)	x
Males, 40–59	2	193	62.18	—	<LOD	<LOD	1.5^E (<LOD - 2.2)	x
Males, 60–79	2	141	77.30	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1267	76.40	—	<LOD	<LOD	<LOD	2.5 (2.0 - 2.9)
Females, 6–11	2	251	72.11	—	<LOD	<LOD	1.4 (1.1 - 1.8)	3.0 (2.1 - 3.8)
Females, 12–19	2	255	67.06	—	<LOD	<LOD	1.7 (1.1 - 2.3)	3.2^E (1.8 - 4.5)
Females, 20–39	2	188	77.66	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	164	82.32	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	148	85.14	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 8.2.4.3

Monomethylarsonic acid (MMA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2528	73.30	—	<LOD	<LOD	1.5 (<LOD - 1.7)	3.4 (2.6 - 4.2)
3–5	2	515	78.06	—	<LOD	<LOD	<LOD	5.0 (3.7 - 6.2)
6–11	2	509	76.82	—	<LOD	<LOD	<LOD (<LOD - 2.0)	3.3 (2.7 - 3.9)
12–19	2	508	63.19	—	<LOD	<LOD	1.1 (0.88 - 1.4)	2.6[E] (1.5 - 3.7)
20–39	2	353	70.54	—	<LOD	<LOD	1.4 (1.1 - 1.8)	3.3[E] (1.7 - 5.0)
40–59	2	355	71.83	—	<LOD	<LOD	1.3 (<LOD - 1.6)	3.2 (2.1 - 4.4)
60–79	2	288	81.60	—	<LOD	<LOD	<LOD	3.6 (2.5 - 4.7)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.4.4

Monomethylarsonic acid (MMA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1267	69.85	—	<LOD	<LOD	1.3 (1.2 - 1.5)	2.9 (2.0 - 3.8)
Males, 6–11	2	259	81.08	—	<LOD	<LOD	<LOD	3.4 (2.5 - 4.2)
Males, 12–19	2	254	59.06	—	<LOD	<LOD	1.0 (0.77 - 1.3)	2.2 (1.7 - 2.7)
Males, 20–39	2	166	62.05	—	<LOD	<LOD	1.3 (0.93 - 1.7)	x
Males, 40–59	2	193	62.18	—	<LOD	<LOD	1.3 (<LOD - 1.7)	x
Males, 60–79	2	141	77.30	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1261	76.76	—	<LOD	<LOD	<LOD	4.0 (3.2 - 4.9)
Females, 6–11	2	250	72.40	—	<LOD	<LOD	1.7 (1.5 - 2.0)	3.3 (2.2 - 4.4)
Females, 12–19	2	254	67.32	—	<LOD	<LOD	1.4 (1.1 - 1.7)	3.5[E] (1.7 - 5.3)
Females, 20–39	2	187	78.07	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	162	83.33	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	147	85.71	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

8.2.5 Dimethylarsinic Acid (DMA)

Table 8.2.5.1

Dimethylarsinic acid (DMA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2538	3.78	6.5 (5.6 - 7.5)	1.9 (1.7 - 2.2)	6.6 (5.6 - 7.5)	11 (9.0 - 14)	30[E] (13 - 47)
3–5	2	516	3.68	6.8 (5.8 - 7.9)	2.6 (2.2 - 3.1)	6.4 (5.6 - 7.3)	12 (9.6 - 14)	24[E] (14 - 34)
6–11	2	511	2.74	7.2 (6.5 - 8.1)	2.7 (2.2 - 3.2)	7.6 (6.5 - 8.7)	12 (10 - 13)	26[E] (15 - 37)
12–19	2	510	2.75	6.7 (5.3 - 8.5)	2.2 (1.4 - 2.9)	6.4 (4.7 - 8.2)	12 (8.2 - 15)	32[E] (17 - 47)
20–39	2	355	5.63	6.8 (5.4 - 8.5)	1.9 (1.4 - 2.5)	7.2 (5.5 - 8.8)	12 (8.2 - 17)	40[E] (20 - 60)
40–59	2	357	5.32	5.9 (4.8 - 7.2)	1.7[E] (<LOD - 2.5)	5.8 (4.6 - 7.0)	10 (7.7 - 13)	22 (16 - 28)
60–79	2	289	3.46	6.7 (5.3 - 8.4)	1.9 (1.5 - 2.4)	6.6 (5.4 - 7.8)	13[E] (8.2 - 18)	38[E] (13 - 63)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.5.2

Dimethylarsinic acid (DMA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1271	3.15	6.7 (5.7 - 8.0)	2.0 (1.4 - 2.6)	6.7 (5.1 - 8.3)	13 (9.8 - 15)	30[E] (15 - 45)
Males, 6–11	2	260	3.46	7.3 (6.1 - 8.8)	2.9 (2.4 - 3.5)	8.1 (6.1 - 10)	10 (8.7 - 12)	24[E] (11 - 38)
Males, 12–19	2	255	1.18	6.6 (5.3 - 8.2)	2.4 (1.6 - 3.2)	6.1 (4.5 - 7.6)	10 (7.0 - 13)	28[E] (13 - 43)
Males, 20–39	2	167	4.79	7.1[E] (4.7 - 11)	F	7.8 (5.0 - 11)	13[E] (3.8 - 22)	x
Males, 40–59	2	193	3.11	6.1 (4.6 - 8.2)	1.7[E] (<LOD - 2.7)	6.1[E] (3.2 - 8.9)	12 (8.1 - 16)	x
Males, 60–79	2	141	2.84	7.2 (5.2 - 9.9)	2.3[E] (1.4 - 3.3)	6.9 (4.6 - 9.2)	13 (8.6 - 18)	x
Females, Total 3–79	2	1267	4.42	6.2 (5.3 - 7.3)	1.9 (1.4 - 2.4)	6.4 (5.6 - 7.3)	10 (8.0 - 13)	33[E] (14 - 53)
Females, 6–11	2	251	1.99	7.1 (6.1 - 8.4)	2.3 (1.5 - 3.1)	7.5 (6.5 - 8.5)	13 (11 - 15)	28[E] (16 - 39)
Females, 12–19	2	255	4.31	6.9 (5.1 - 9.4)	2.0[E] (<LOD - 3.4)	7.3 (5.2 - 9.3)	14 (9.1 - 18)	33[E] (18 - 48)
Females, 20–39	2	188	6.38	6.4 (4.8 - 8.7)	2.0 (1.5 - 2.5)	6.7 (4.8 - 8.6)	9.9[E] (5.8 - 14)	x
Females, 40–59	2	164	7.93	5.7 (4.4 - 7.2)	F	5.7 (4.4 - 7.0)	9.5 (7.0 - 12)	x
Females, 60–79	2	148	4.05	6.2 (4.6 - 8.5)	1.6[E] (1.0 - 2.2)	5.8[E] (3.6 - 8.0)	11[E] (4.3 - 18)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 8.2.5.3

Dimethylarsinic acid (DMA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2528	3.80	6.4 (5.6 - 7.4)	2.7 (2.4 - 3.0)	5.8 (5.0 - 6.5)	10 (8.3 - 12)	29[E] (18 - 39)
3–5	2	515	3.69	12 (10 - 13)	5.5 (4.8 - 6.1)	10 (8.7 - 12)	16 (13 - 19)	44[E] (19 - 68)
6–11	2	509	2.75	8.4 (7.5 - 9.3)	4.0 (3.7 - 4.4)	8.0 (7.2 - 8.8)	12 (9.8 - 14)	34[E] (20 - 47)
12–19	2	508	2.76	5.2 (4.2 - 6.4)	2.1 (1.6 - 2.6)	4.6 (3.5 - 5.6)	7.7 (5.6 - 9.9)	26[E] (15 - 36)
20–39	2	353	5.67	5.8 (4.6 - 7.2)	2.4 (2.1 - 2.8)	4.9 (3.6 - 6.2)	9.4 (6.5 - 12)	29[E] (15 - 44)
40–59	2	355	5.35	6.0 (5.3 - 6.8)	2.9 (<LOD - 3.3)	5.6 (5.0 - 6.2)	8.6 (7.1 - 10)	20[E] (12 - 29)
60–79	2	288	3.47	7.8 (6.3 - 9.8)	2.7 (2.2 - 3.2)	7.6 (5.8 - 9.3)	13 (9.6 - 16)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.2.5.4

Dimethylarsinic acid (DMA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1267	3.16	5.8 (4.9 - 6.7)	2.5 (2.1 - 2.9)	5.3 (4.5 - 6.2)	8.9 (7.4 - 10)	22[E] (12 - 32)
Males, 6–11	2	259	3.47	8.4 (7.2 - 9.7)	4.3 (3.4 - 5.2)	8.0 (7.2 - 8.8)	12 (8.8 - 15)	27[E] (15 - 40)
Males, 12–19	2	254	1.18	4.7 (3.8 - 5.8)	2.1 (1.7 - 2.4)	4.0 (3.1 - 4.9)	6.6 (4.9 - 8.2)	24[E] (13 - 35)
Males, 20–39	2	166	4.82	5.2 (3.6 - 7.3)	1.9[E] (<LOD - 2.9)	4.4[E] (2.0 - 6.9)	8.8[E] (5.5 - 12)	x
Males, 40–59	2	193	3.11	5.4 (4.5 - 6.3)	2.8 (<LOD - 3.3)	5.0 (4.1 - 5.8)	7.4 (6.0 - 8.7)	x
Males, 60–79	2	141	2.84	6.8 (5.2 - 8.9)	2.6 (1.8 - 3.5)	6.0 (4.0 - 8.0)	10 (8.2 - 12)	x
Females, Total 3–79	2	1261	4.44	7.1 (6.1 - 8.4)	2.9 (2.6 - 3.2)	6.3 (5.4 - 7.2)	12 (9.4 - 15)	34[E] (21 - 46)
Females, 6–11	2	250	2.00	8.4 (7.3 - 9.6)	4.0 (3.4 - 4.5)	7.5 (6.4 - 8.7)	12 (8.9 - 14)	35[E] (21 - 49)
Females, 12–19	2	254	4.33	5.7 (4.5 - 7.4)	2.3 (<LOD - 3.1)	5.2 (3.9 - 6.5)	8.9 (6.2 - 12)	28[E] (15 - 41)
Females, 20–39	2	187	6.42	6.5 (5.0 - 8.4)	2.7 (2.3 - 3.2)	5.0 (3.9 - 6.1)	10[E] (4.7 - 15)	x
Females, 40–59	2	162	8.02	6.8 (5.8 - 7.9)	2.9 (<LOD - 3.6)	6.3 (5.4 - 7.2)	10 (8.1 - 12)	x
Females, 60–79	2	147	4.08	8.9 (6.8 - 12)	2.7 (2.0 - 3.4)	8.5[E] (5.1 - 12)	15 (9.7 - 20)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

The organoarsenic compounds, arsenobetaine and arsenocholine, were measured together in the urine of all CHMS cycle 2 (2009–2011) participants aged 3 to 79 years. The data are presented as both µg/L and µg/g creatinine (Tables 8.2.6.1, 8.2.6.2, 8.2.6.3, and 8.2.6.4).

8.2.6 Arsenocholine and Arsenobetaine

Table 8.2.6.1

Arsenocholine and arsenobetaine — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2538	48.50	—	<LOD	3.4^{E} (<LOD - 5.2)	16^{E} (8.7 - 23)	110^{E} (70 - 160)
3–5	2	516	59.69	—	<LOD	<LOD	6.9^{E} (2.0 - 12)	82^{E} (47 - 120)
6–11	2	511	58.12	—	<LOD	<LOD	6.5^{E} (3.3 - 9.7)	F
12–19	2	510	57.65	—	<LOD	<LOD	F	89^{E} (38 - 140)
20–39	2	355	38.59	5.3^{E} (3.4 - 8.4)	<LOD	F	F	F
40–59	2	357	30.81	4.3 (3.2 - 5.7)	<LOD	3.5^{E} (<LOD - 5.9)	12^{E} (6.1 - 17)	85^{E} (45 - 130)
60–79	2	289	29.41	8.5^{E} (5.2 - 14)	<LOD	8.5^{E} (3.4 - 14)	37^{E} (18 - 55)	180^{E} (78 - 270)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.2.6.2

Arsenocholine and arsenobetaine — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1271	46.34	—	<LOD	3.7^{E} (<LOD - 5.9)	18^{E} (8.1 - 27)	F
Males, 6–11	2	260	59.23	—	<LOD	<LOD	F	49^{E} (30 - 68)
Males, 12–19	2	255	53.73	—	<LOD	<LOD	F	88^{E} (26 - 150)
Males, 20–39	2	167	35.33	F	<LOD	F	F	x
Males, 40–59	2	193	26.94	4.9^{E} (3.2 - 7.6)	<LOD	F	F	x
Males, 60–79	2	141	26.24	9.8^{E} (5.3 - 18)	<LOD	F	35^{E} (17 - 54)	x
Females, Total 3–79	2	1267	50.67	—	<LOD	F	14^{E} (7.7 - 21)	120^{E} (69 - 170)
Females, 6–11	2	251	56.97	—	<LOD	<LOD	F	F
Females, 12–19	2	255	61.57	—	<LOD	<LOD	F	F
Females, 20–39	2	188	41.49	—	<LOD	F	F	x
Females, 40–59	2	164	35.37	3.7 (2.7 - 5.1)	<LOD	F	12^{E} (5.4 - 19)	x
Females, 60–79	2	148	32.43	7.5^{E} (3.8 - 15)	<LOD	F	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 8.2.6.3

Arsenocholine and arsenobetaine (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2528	48.69	—	<LOD	3.6^{E} (<LOD - 5.7)	17 (11 - 22)	110^{E} (43 - 170)
3–5	2	515	59.81	—	<LOD	<LOD	12^{E} (5.5 - 19)	F
6–11	2	509	58.35	—	<LOD	<LOD	7.1^{E} (2.4 - 12)	F
12–19	2	508	57.87	—	<LOD	<LOD	5.7^{E} (<LOD - 9.2)	58^{E} (25 - 92)
20–39	2	353	38.81	4.4^{E} (2.8 - 6.8)	<LOD	F	17^{E} (6.9 - 26)	F
40–59	2	355	30.99	4.4 (3.2 - 6.0)	<LOD	F	13^{E} (6.5 - 19)	57^{E} (21 - 94)
60–79	2	288	29.51	10^{E} (6.1 - 16)	<LOD	11^{E} (4.3 - 18)	43^{E} (23 - 63)	200^{E} (100 - 290)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.2.6.4

Arsenocholine and arsenobetaine (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1267	46.49	—	<LOD	3.0^{E} (<LOD - 5.0)	14^{E} (8.2 - 21)	F
Males, 6–11	2	259	59.46	—	<LOD	<LOD	F	54^{E} (28 - 81)
Males, 12–19	2	254	53.94	—	<LOD	<LOD	6.4^{E} (<LOD - 10)	82^{E} (31 - 130)
Males, 20–39	2	166	35.54	3.5^{E} (1.7 - 7.0)	<LOD	F	17^{E} (<LOD - 26)	x
Males, 40–59	2	193	26.94	4.3^{E} (2.7 - 6.8)	<LOD	F	10^{E} (<LOD - 16)	x
Males, 60–79	2	141	26.24	9.3^{E} (5.0 - 17)	<LOD	F	36^{E} (20 - 53)	x
Females, Total 3–79	2	1261	50.91	—	<LOD	4.1^{E} (<LOD - 6.9)	18^{E} (12 - 25)	150^{E} (48 - 240)
Females, 6–11	2	250	57.20	—	<LOD	<LOD	9.4^{E} (<LOD - 14)	F
Females, 12–19	2	254	61.81	—	<LOD	<LOD	F	F
Females, 20–39	2	187	41.71	—	<LOD	5.0^{E} (<LOD - 7.9)	F	x
Females, 40–59	2	162	35.80	4.5^{E} (2.9 - 6.9)	<LOD	<LOD (<LOD - 7.7)	18^{E} (10 - 26)	x
Females, 60–79	2	147	32.65	11^{E} (5.7 - 20)	<LOD	F	50^{E} (<LOD - 76)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Finding a measurable amount of arsenic in urine is an indicator of exposure to arsenic and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary speciated arsenic, methylated arsenic metabolites, and organoarsenic compounds in the Canadian population.

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8.3 CADMIUM

Cadmium (CASRN 7440-43-9) is among the least abundant metals in the Earth's crust at an average concentration of approximately 0.00001% (Emsley, 2001). It is a naturally occurring soft, silvery white, blue-tinged metal. Cadmium often occurs in zinc ores (Health Canada, 1986). Common forms include soluble and insoluble species that may also be found as particulate matter in the atmosphere (ATSDR, 2008; CCME, 1999).

Cadmium is released to the environment as a result of natural processes, including forest fires, volcanic emissions, and weathering of soil and bedrock (Morrow, 2000). The main anthropogenic sources of atmospheric cadmium are industrial base-metal smelting and refining processes, and combustion processes such as coal-fired electrical plants and waste incineration where cadmium is released as a by-product (CCME, 1999).

Cadmium is primarily used in the manufacture of nickel-cadmium batteries (USGS, 2012). It is also used in industrial coatings and electroplating, in pigments, and as a stabilizer in polyvinyl chloride plastics. Cadmium is present in metal alloy sheets, wires, rods, solders, and shields for various industrial applications (Environment Canada & Health Canada, 1994). It is also sometimes used as a pigment in ceramic glazes. Cadmium may also be present in fertilizers as the result of recycling of by-products and waste materials for land application. It is frequently an impurity in galvanized pipes and can leach into drinking water (Health Canada, 1986).

In smokers, inhalation of cigarette smoke is the major source of cadmium exposure (Environment Canada & Health Canada, 1994; IARC, 2012). For non-smoking adults and children, the largest source of cadmium exposure is through the ingestion of food (IARC, 2012). Ambient air is a minor source of exposure with intakes estimated to be two to three orders of magnitude lower than food, although cadmium compounds are more readily absorbed following inhalation than ingestion (Friberg, 1985). Other minor sources of exposure include ingestion of drinking water, soil, or dust (ATSDR, 2008; Environment Canada & Health Canada, 1994).

Absorption of dietary cadmium into the bloodstream depends on an individual's nutritional status and the levels of other components of the diet such as iron, calcium, and protein. The average gastrointestinal absorption of dietary cadmium is estimated at 5% in adult men and 10% or higher in women (CDC, 2009). About 25% to 60% of inhaled cadmium is absorbed through the lungs (ATSDR, 2008). Absorbed cadmium accumulates mainly in the kidney and liver, with approximately one-third to one-half of the total body burden accumulating in the kidney (CDC, 2009). The biological half-life of cadmium in the kidney has been estimated to be approximately 10 to 12 years (Amzal et al., 2009; Lauwerys et al., 1994). Only a small proportion of absorbed cadmium is eliminated, mainly in the urine and feces with small amounts also eliminated through hair, nails, and sweat.

Cadmium can be measured in blood, urine, feces, liver, kidney, and hair among other tissues. Cadmium concentrations in urine best reflect cumulative exposure and the concentration of cadmium in the kidney, although slight fluctuations occur with recent exposures (CDC, 2009). Concentrations in blood reflect both recent and cumulative exposures (CDC, 2009). Blood cadmium concentrations are about twice as high in smokers compared with non-smokers; concentrations can also be elevated following occupational exposures (ATSDR, 2008).

Oral exposure to high doses of cadmium may cause severe gastrointestinal irritation and kidney effects (ATSDR, 2008). Chronic exposure via inhalation has been associated with effects in the lungs, including emphysema, and in the kidneys (ATSDR, 2008). The kidney is the critical organ that exhibits the first adverse effects following both oral and inhalation exposure (Lauwerys et al., 1994).

Cadmium and its compounds have been classified as carcinogenic to humans (Group 1) by the International Agency for Research on Cancer, based on various data including associations between occupational inhalation exposure and lung cancer (IARC, 2012). There is insufficient evidence to determine whether or not cadmium is carcinogenic following oral exposure (ATSDR, 2008).

Health Canada and Environment Canada concluded that inorganic cadmium compounds are a concern for human health (Environment Canada & Health Canada, 1994). Inorganic cadmium compounds are listed on Schedule 1, List of Toxic Substances, under the *Canadian Environmental Protection Act, 1999* (CEPA 1999). The Act allows the federal government to control the importation, manufacture, distribution, and use of inorganic cadmium compounds in Canada (Canada, 1999; Canada, 2000). Risk management actions under CEPA 1999 have been developed to control releases of cadmium from thermal electric power generation, base-metal smelting, and steel manufacturing processes (Environment Canada, 2010).

In Canada, the leachable cadmium content in a variety of consumer products is regulated under the *Canada Consumer Product Safety Act* (Canada, 2010a). Consumer products regulated for leachable cadmium content include glazed ceramics and glassware, as well as paints and other surface coatings on cribs, toys, and other products for use by a child in learning or play situations (Canada, 1998; Canada, 2010b; Canada, 2011; Health Canada, 2009a). In addition, since children's jewellery items containing high levels of cadmium have been found on the Canadian marketplace, a guideline limit for total cadmium in children's jewellery was proposed by Health Canada in 2011 (Health Canada, 2011a). Cadmium and its compounds are included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011b). On the basis of health considerations, Health Canada has developed a Canadian drinking water quality guideline that sets out the maximum acceptable concentration of cadmium (Health Canada, 1986). Cadmium is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009b). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply.

In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric means for cadmium in urine and whole blood were 0.54 µg/L and 0.69 µg/L, respectively (INSPQ, 2004).

Cadmium was measured in the whole blood and urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented in blood as µg/L (Tables 8.3.1, 8.3.2, and 8.3.3) and in urine as both µg/L (Tables 8.3.4, 8.3.5, and 8.3.6) and µg/g creatinine (Tables 8.3.7, 8.3.8, and 8.3.9). Finding a measurable amount of cadmium in blood or urine is an indicator of exposure to cadmium and does not necessarily mean that an adverse health effect will occur.

Table 8.3.1

Cadmium — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5319	2.91	0.34 (0.31 - 0.37)	0.091 (0.087 - 0.094)	0.27 (0.25 - 0.29)	0.62 (0.55 - 0.70)	3.6 (3.1 - 4.1)
Total, 6–79	2	5575	4.27	0.31 (0.28 - 0.34)	0.088 (0.077 - 0.099)	0.27 (0.25 - 0.30)	0.57 (0.51 - 0.63)	2.6 (2.1 - 3.1)
Males, Total 6–79	1	2576	3.34	0.30 (0.27 - 0.34)	0.084 (0.073 - 0.095)	0.22 (0.20 - 0.25)	0.58 (0.43 - 0.72)	3.4 (2.8 - 4.0)
Males, Total 6–79	2	2687	4.84	0.28 (0.25 - 0.31)	0.083 (0.071 - 0.094)	0.24 (0.22 - 0.26)	0.54 (0.48 - 0.60)	2.5 (1.9 - 3.0)
Females, Total 6–79	1	2743	2.52	0.38 (0.35 - 0.41)	0.093 (0.091 - 0.095)	0.32 (0.29 - 0.36)	0.65 (0.56 - 0.74)	3.7 (3.1 - 4.3)
Females, Total 6–79	2	2888	3.74	0.34 (0.29 - 0.38)	0.095 (0.084 - 0.11)	0.31 (0.28 - 0.34)	0.59 (0.45 - 0.73)	2.7 (2.1 - 3.4)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.2

Cadmium — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6070	5.16	0.29 (0.27 - 0.32)	0.083 (0.071 - 0.094)	0.26 (0.24 - 0.29)	0.54 (0.49 - 0.59)	2.6 (2.1 - 3.0)
3–5[b]	1							
3–5	2	495	15.15	0.075 (0.067 - 0.084)	<LOD	0.076 (0.066 - 0.087)	0.10 (0.096 - 0.11)	0.14[E] (0.041 - 0.24)
6–11	1	910	9.12	0.091 (0.082 - 0.10)	<LOD[E] (<LOD - 0.053)	0.092 (0.090 - 0.094)	0.098 (0.084 - 0.11)	0.22 (0.19 - 0.26)
6–11	2	961	14.05	0.086 (0.079 - 0.094)	<LOD	0.090 (0.084 - 0.097)	0.11 (0.11 - 0.11)	0.20 (0.18 - 0.23)
12–19	1	945	3.92	0.16 (0.13 - 0.20)	0.066 (0.045 - 0.086)	F	0.21 (0.19 - 0.23)	F
12–19	2	997	5.72	0.14 (0.12 - 0.16)	0.059 (0.042 - 0.075)	0.11 (0.10 - 0.11)	0.19 (0.17 - 0.21)	0.82[E] (0.42 - 1.2)
20–39	1	1165	1.55	0.34 (0.30 - 0.38)	0.091 (0.084 - 0.098)	0.24 (0.21 - 0.27)	0.68 (0.43 - 0.92)	3.4 (3.1 - 3.7)
20–39	2	1313	2.21	0.29 (0.24 - 0.35)	0.093 (0.062 - 0.12)	0.24 (0.20 - 0.28)	0.53[E] (0.33 - 0.74)	2.7 (2.1 - 3.2)
40–59	1	1220	0.90	0.48 (0.43 - 0.54)	0.098[E] (0.049 - 0.15)	0.36 (0.32 - 0.41)	0.98 (0.73 - 1.2)	4.2 (3.7 - 4.7)
40–59	2	1222	0.98	0.42 (0.37 - 0.47)	0.11 (0.10 - 0.11)	0.34 (0.31 - 0.37)	0.78 (0.52 - 1.0)	3.1 (2.4 - 3.8)
60–79	1	1079	0.56	0.45 (0.41 - 0.49)	0.19 (0.18 - 0.20)	0.39 (0.37 - 0.41)	0.71 (0.59 - 0.82)	2.7 (2.2 - 3.2)
60–79	2	1082	0.46	0.46 (0.41 - 0.51)	0.18 (0.13 - 0.22)	0.40 (0.35 - 0.44)	0.72 (0.63 - 0.81)	2.3 (1.9 - 2.8)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.3.3

Cadmium — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2940	5.78	0.27 (0.24 - 0.30)	0.078 (0.067 - 0.088)	0.23 (0.21 - 0.25)	0.53 (0.46 - 0.60)	2.4 (1.9 - 2.9)
Males, 6–11	1	459	9.59	0.088 (0.079 - 0.098)	<LOD	0.091 (0.088 - 0.094)	0.098 (0.074 - 0.12)	0.21 (0.15 - 0.27)
Males, 6–11	2	488	13.11	0.086 (0.077 - 0.096)	<LOD	0.089 (0.082 - 0.096)	0.11 (0.10 - 0.11)	0.21 (0.15 - 0.26)
Males, 12–19	1	489	3.48	0.16 (0.13 - 0.19)	0.058[E] (<LOD - 0.080)	0.098[E] (0.047 - 0.15)	0.20 (0.18 - 0.22)	F
Males, 12–19	2	523	7.07	0.15 (0.12 - 0.18)	0.062 (0.044 - 0.081)	0.11 (0.10 - 0.11)	0.20 (0.14 - 0.25)	F
Males, 20–39	1	514	2.14	0.32 (0.26 - 0.40)	0.083 (0.061 - 0.11)	0.21 (0.16 - 0.25)	0.77[E] (0.41 - 1.1)	3.6 (3.1 - 4.1)
Males, 20–39	2	552	3.08	0.26 (0.21 - 0.31)	0.081 (0.056 - 0.11)	0.20 (0.14 - 0.26)	0.50[E] (0.29 - 0.71)	2.7[E] (1.6 - 3.8)
Males, 40–59	1	577	1.73	0.40 (0.32 - 0.49)	0.094 (0.090 - 0.098)	0.28 (0.24 - 0.31)	0.85[E] (0.36 - 1.4)	3.9 (2.9 - 4.9)
Males, 40–59	2	617	1.46	0.38 (0.33 - 0.44)	0.10 (0.10 - 0.11)	0.31 (0.26 - 0.35)	0.84[E] (0.40 - 1.3)	2.9 (2.2 - 3.5)
Males, 60–79	1	537	0.74	0.41 (0.35 - 0.48)	0.18 (0.13 - 0.23)	0.35 (0.31 - 0.39)	0.66 (0.43 - 0.89)	2.7 (1.8 - 3.6)
Males, 60–79	2	507	0.59	0.42 (0.37 - 0.49)	0.15[E] (0.084 - 0.21)	0.37 (0.32 - 0.41)	0.69 (0.59 - 0.78)	2.3 (1.5 - 3.0)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3130	4.57	0.32 (0.28 - 0.37)	0.089 (0.076 - 0.10)	0.30 (0.27 - 0.33)	0.57 (0.45 - 0.69)	2.7 (2.1 - 3.4)
Females, 6–11	1	451	8.65	0.094 (0.083 - 0.11)	0.040[E] (<LOD - 0.068)	0.093 (0.091 - 0.095)	0.099 (0.075 - 0.12)	0.23 (0.19 - 0.26)
Females, 6–11	2	473	15.01	0.086 (0.077 - 0.096)	<LOD	0.093 (0.083 - 0.10)	0.11 (0.11 - 0.11)	0.20 (0.17 - 0.24)
Females, 12–19	1	456	4.39	0.17 (0.14 - 0.21)	0.080 (0.065 - 0.095)	0.18[E] (0.095 - 0.26)	0.22 (0.19 - 0.26)	F
Females, 12–19	2	474	4.22	0.13 (0.12 - 0.15)	0.053[E] (<LOD - 0.073)	0.11 (0.10 - 0.11)	0.19 (0.16 - 0.21)	0.68[E] (0.31 - 1.1)
Females, 20–39	1	651	1.08	0.36 (0.31 - 0.41)	0.093 (0.091 - 0.095)	0.27 (0.22 - 0.32)	0.63 (0.46 - 0.80)	3.2 (2.7 - 3.7)
Females, 20–39	2	761	1.58	0.33 (0.25 - 0.44)	0.10 (0.068 - 0.14)	0.28 (0.21 - 0.36)	F	2.6[E] (1.7 - 3.6)
Females, 40–59	1	643	0.16	0.58 (0.51 - 0.66)	0.19 (0.17 - 0.22)	0.43 (0.37 - 0.50)	1.1[E] (0.61 - 1.5)	4.4 (4.0 - 4.8)
Females, 40–59	2	605	0.50	0.47 (0.38 - 0.56)	F	0.38 (0.34 - 0.43)	0.76[E] (0.46 - 1.1)	3.3 (2.5 - 4.2)
Females, 60–79	1	542	0.37	0.49 (0.44 - 0.56)	0.20 (0.18 - 0.21)	0.42 (0.37 - 0.48)	0.75 (0.64 - 0.86)	2.7 (1.9 - 3.5)
Females, 60–79	2	575	0.35	0.49 (0.45 - 0.54)	0.20 (0.16 - 0.25)	0.43 (0.39 - 0.47)	0.77 (0.66 - 0.88)	2.6 (2.0 - 3.1)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.3.4

Cadmium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5491	9.71	0.34 (0.31 - 0.38)	<LOD[E] (<LOD - 0.11)	0.37 (0.34 - 0.41)	0.67 (0.62 - 0.72)	1.6 (1.5 - 1.7)
Total, 6–79	2	5738	6.12	0.40 (0.36 - 0.44)	0.10 (0.093 - 0.11)	0.42 (0.36 - 0.48)	0.77 (0.68 - 0.85)	1.9 (1.6 - 2.1)
Males, Total 6–79	1	2661	8.27	0.36 (0.33 - 0.39)	0.091 (<LOD - 0.11)	0.39 (0.36 - 0.43)	0.68 (0.63 - 0.74)	1.6 (1.4 - 1.7)
Males, Total 6–79	2	2746	5.35	0.39 (0.34 - 0.45)	0.10 (0.087 - 0.12)	0.41 (0.35 - 0.48)	0.76 (0.63 - 0.89)	1.6 (1.3 - 1.9)
Females, Total 6–79	1	2830	11.06	0.33 (0.29 - 0.37)	<LOD	0.36 (0.33 - 0.39)	0.66 (0.60 - 0.72)	1.7 (1.5 - 1.9)
Females, Total 6–79	2	2992	6.82	0.40 (0.37 - 0.44)	0.10 (0.094 - 0.11)	0.42 (0.36 - 0.48)	0.77 (0.70 - 0.84)	2.0 (1.6 - 2.4)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.3.5

Cadmium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6311	6.56	0.39 (0.35 - 0.44)	0.10 (0.091 - 0.11)	0.41 (0.35 - 0.47)	0.75 (0.66 - 0.84)	1.8 (1.6 - 2.0)
3–5[b]	1							
3–5	2	573	10.99	0.23 (0.19 - 0.28)	<LOD	0.25 (0.21 - 0.30)	0.40 (0.33 - 0.47)	F
6–11	1	1033	14.71	0.22 (0.18 - 0.25)	<LOD	0.25 (0.20 - 0.29)	0.42 (0.37 - 0.46)	0.72 (0.60 - 0.85)
6–11	2	1062	9.70	0.25 (0.21 - 0.30)	0.076 (<LOD - 0.095)	0.27 (0.21 - 0.32)	0.43 (0.33 - 0.54)	0.86 (0.64 - 1.1)
12–19	1	983	10.48	0.27 (0.23 - 0.31)	<LOD	0.32 (0.28 - 0.36)	0.48 (0.42 - 0.53)	0.89 (0.66 - 1.1)
12–19	2	1041	7.59	0.27 (0.22 - 0.32)	0.090 (<LOD - 0.12)	0.30 (0.24 - 0.36)	0.47 (0.38 - 0.56)	0.81 (0.68 - 0.94)
20–39	1	1169	13.17	0.27 (0.25 - 0.31)	<LOD	0.31 (0.27 - 0.36)	0.54 (0.49 - 0.59)	1.1 (0.99 - 1.3)
20–39	2	1321	7.12	0.34 (0.29 - 0.39)	0.087[E] (<LOD - 0.12)	0.36 (0.30 - 0.43)	[illegible]6 (0.[illegible]3 - [illegible].79)	1.2 (1.0 - 1.4)
40–59	1	1223	7.36	0.42 (0.38 - 0.46)	0.093 (<LOD - 0.10)	0.45 (0.40 - 0.51)	0.81 (0.74 - 0.87)	2.1 (1.7 - 2.4)
40–59	2	1228	4.64	0.50 (0.44 - 0.56)	0.11 (0.095 - 0.12)	0.53 (0.44 - 0.62)	0.98 (0.84 - 1.1)	2.5 (2.0 - 3.0)
60–79	1	1083	3.14	0.50 (0.44 - 0.56)	0.099 (<LOD - 0.13)	0.51 (0.46 - 0.56)	0.98 (0.89 - 1.1)	2.2 (1.9 - 2.6)
60–79	2	1086	1.66	0.54 (0.47 - 0.62)	0.11 (0.091 - 0.13)	0.58 (0.50 - 0.65)	1.0 (0.93 - 1.1)	2.5 (2.0 - 2.9)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.3.6

Cadmium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	5.67	0.39 (0.34 - 0.45)	0.10 (0.085 - 0.12)	0.41 (0.34 - 0.47)	0.74 (0.61 - 0.86)	1.6 (1.3 - 1.8)
Males, 6–11	1	523	13.00	0.22 (0.18 - 0.27)	<LOD	0.25 (0.18 - 0.33)	0.42 (0.36 - 0.47)	0.71 (0.59 - 0.83)
Males, 6–11	2	532	7.52	0.27 (0.21 - 0.35)	0.089 (<LOD - 0.11)	0.29 (0.22 - 0.37)	0.47 (0.30 - 0.63)	0.95 (0.68 - 1.2)
Males, 12–19	1	505	8.12	0.27 (0.24 - 0.31)	0.091[E] (<LOD - 0.13)	0.31 (0.27 - 0.35)	0.45 (0.39 - 0.51)	0.77 (0.55 - 0.98)
Males, 12–19	2	542	6.09	0.29 (0.23 - 0.37)	0.10 (0.084 - 0.12)	0.31 (0.24 - 0.39)	0.48 (0.34 - 0.62)	0.85 (0.68 - 1.0)
Males, 20–39	1	514	11.87	0.28 (0.24 - 0.32)	<LOD	0.33 (0.28 - 0.38)	0.54 (0.46 - 0.62)	1.1 (0.97 - 1.2)
Males, 20–39	2	551	6.53	0.32 (0.27 - 0.39)	0.074[E] (<LOD - 0.11)	0.35 (0.27 - 0.43)	0.65 (0.47 - 0.83)	1.3[E] (0.81 - 1.9)
Males, 40–59	1	578	6.57	0.43 (0.38 - 0.49)	0.094 (<LOD - 0.11)	0.48 (0.42 - 0.55)	0.81 (0.71 - 0.92)	1.9 (1.5 - 2.3)
Males, 40–59	2	616	5.36	0.48 (0.41 - 0.57)	0.11[E] (<LOD - 0.16)	0.57 (0.46 - 0.68)	1.0 (0.78 - 1.2)	1.8 (1.2 - 2.4)
Males, 60–79	1	541	2.22	0.56 (0.50 - 0.64)	0.15[E] (0.094 - 0.21)	0.58 (0.52 - 0.64)	1.0 (0.87 - 1.1)	2.3 (1.7 - 2.8)
Males, 60–79	2	505	0.99	0.54 (0.44 - 0.66)	0.11[E] (<LOD - 0.16)	0.55 (0.42 - 0.67)	1.0 (0.82 - 1.2)	2.4 (1.7 - 3.1)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	7.39	0.39 (0.36 - 0.43)	0.10 (0.092 - 0.11)	0.41 (0.35 - 0.47)	0.76 (0.69 - 0.83)	2.0 (1.6 - 2.4)
Females, 6–11	1	510	16.47	0.21 (0.18 - 0.26)	<LOD	0.24 (0.19 - 0.29)	0.42 (0.36 - 0.47)	0.73 (0.57 - 0.89)
Females, 6–11	2	530	11.89	0.23 (0.19 - 0.27)	<LOD	0.25 (0.21 - 0.29)	0.40 (0.32 - 0.49)	0.81 (0.57 - 1.1)
Females, 12–19	1	478	12.97	0.27 (0.22 - 0.32)	<LOD	0.34 (0.28 - 0.39)	0.52 (0.42 - 0.62)	0.97 (0.68 - 1.3)
Females, 12–19	2	499	9.22	0.24 (0.20 - 0.29)	0.076[E] (<LOD - 0.11)	0.28 (0.22 - 0.34)	0.46 (0.41 - 0.52)	0.77 (0.69 - 0.84)
Females, 20–39	1	655	14.20	0.27 (0.23 - 0.32)	<LOD	0.29 (0.23 - 0.35)	0.53 (0.44 - 0.62)	1.3 (0.84 - 1.7)
Females, 20–39	2	770	7.53	0.35 (0.29 - 0.41)	0.096 (0.071 - 0.12)	0.37 (0.28 - 0.46)	0.71 (0.55 - 0.86)	1.1 (1.0 - 1.3)
Females, 40–59	1	645	8.06	0.40 (0.35 - 0.46)	0.092 (<LOD - 0.12)	0.41 (0.33 - 0.48)	0.79 (0.71 - 0.86)	2.3 (1.8 - 2.8)
Females, 40–59	2	612	3.92	0.51 (0.43 - 0.61)	0.11 (0.094 - 0.12)	0.51 (0.41 - 0.60)	0.95 (0.62 - 1.3)	2.6 (2.3 - 3.0)
Females, 60–79	1	542	4.06	0.44 (0.37 - 0.52)	0.095[E] (<LOD - 0.13)	0.46 (0.40 - 0.52)	0.90 (0.74 - 1.1)	2.2 (1.8 - 2.6)
Females, 60–79	2	581	2.24	0.54 (0.49 - 0.60)	0.11 (0.097 - 0.12)	0.59 (0.54 - 0.64)	1.1 (0.98 - 1.2)	2.5 (2.1 - 3.0)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.3.7

Cadmium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5478	9.73	0.42 (0.40 - 0.44)	<LOD (<LOD - 0.18)	0.39 (0.37 - 0.41)	0.68 (0.63 - 0.74)	1.5 (1.4 - 1.7)
Total, 6–79	2	5719	6.14	0.37 (0.34 - 0.41)	0.14 (0.12 - 0.16)	0.36 (0.32 - 0.40)	0.62 (0.57 - 0.67)	1.4 (1.3 - 1.6)
Males, Total 6–79	1	2652	8.30	0.36 (0.34 - 0.38)	0.15 (<LOD - 0.16)	0.33 (0.31 - 0.35)	0.54 (0.48 - 0.60)	1.2 (1.0 - 1.3)
Males, Total 6–79	2	2739	5.37	0.31 (0.28 - 0.35)	0.13 (0.11 - 0.15)	0.31 (0.26 - 0.35)	0.49 (0.42 - 0.55)	1.1 (0.97 - 1.3)
Females, Total 6–79	1	2826	11.08	0.50 (0.47 - 0.53)	<LOD	0.46 (0.42 - 0.50)	0.80 (0.73 - 0.86)	2.0 (1.7 - 2.2)
Females, Total 6–79	2	2980	6.85	0.44 (0.40 - 0.48)	0.16 (0.14 - 0.19)	0.43 (0.39 - 0.47)	0.74 (0.68 - 0.80)	1.9 (1.5 - 2.4)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.3.8

Cadmium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6291	6.58	0.37 (0.34 - 0.41)	0.14 (0.12 - 0.16)	0.36 (0.32 - 0.40)	0.62 (0.57 - 0.67)	1.4 (1.3 - 1.6)
3–5[b]	1							
3–5	2	572	11.01	0.39 (0.33 - 0.47)	<LOD	0.42 (0.36 - 0.49)	0.58 (0.50 - 0.66)	F
6–11	1	1030	14.76	0.34 (0.31 - 0.38)	<LOD	0.33 (0.30 - 0.37)	0.46 (0.40 - 0.52)	0.86 (0.70 - 1.0)
6–11	2	1058	9.74	0.28 (0.24 - 0.33)	0.12 (<LOD - 0.15)	0.28 (0.24 - 0.32)	0.42 (0.34 - 0.51)	0.80 (0.67 - 0.94)
12–19	1	982	10.49	0.24 (0.22 - 0.26)	<LOD	0.23 (0.22 - 0.25)	0.31 (0.28 - 0.34)	0.53 (0.40 - 0.65)
12–19	2	1039	7.60	0.20 (0.17 - 0.23)	0.099 (<LOD - 0.12)	0.20 (0.18 - 0.23)	0.27 (0.23 - 0.32)	0.46 (0.34 - 0.58)
20–39	1	1165	13.22	0.31 (0.29 - 0.33)	<LOD	0.30 (0.28 - 0.32)	0.45 (0.42 - 0.48)	0.83 (0.68 - 0.97)
20–39	2	1319	7.13	0.28 (0.24 - 0.32)	0.13 (<LOD - 0.14)	0.27 (0.22 - 0.33)	0.43 (0.37 - 0.49)	0.79 (0.69 - 0.88)
40–59	1	1218	7.39	0.54 (0.51 - 0.57)	0.22 (<LOD - 0.25)	0.52 (0.47 - 0.56)	0.86 (0.78 - 0.94)	1.9 (1.6 - 2.2)
40–59	2	1223	4.66	0.47 (0.43 - 0.53)	0.19 (0.16 - 0.22)	0.46 (0.41 - 0.50)	0.77 (0.69 - 0.85)	1.9 (1.3 - 2.4)
60–79	1	1083	3.14	0.70 (0.64 - 0.76)	0.30 (<LOD - 0.33)	0.68 (0.62 - 0.75)	1.1 (0.94 - 1.2)	2.1 (1.8 - 2.4)
60–79	2	1080	1.67	0.64 (0.58 - 0.71)	0.26 (0.22 - 0.29)	0.63 (0.57 - 0.69)	1.0 (0.90 - 1.1)	2.0 (1.7 - 2.3)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

F Data is too unreliable to be published.

Table 8.3.9

Cadmium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	5.68	0.32 (0.28 - 0.35)	0.13 (0.11 - 0.15)	0.31 (0.27 - 0.36)	0.49 (0.43 - 0.55)	1.1 (0.97 - 1.3)
Males, 6–11	1	521	13.05	0.34 (0.32 - 0.37)	<LOD	0.33 (0.31 - 0.36)	0.46 (0.41 - 0.51)	0.83 (0.68 - 0.97)
Males, 6–11	2	530	7.55	0.30 (0.24 - 0.37)	0.13[E] (<LOD - 0.19)	0.30 (0.24 - 0.36)	0.45 (0.35 - 0.56)	0.86 (0.73 - 0.98)
Males, 12–19	1	504	8.13	0.23 (0.21 - 0.25)	0.12 (<LOD - 0.14)	0.22 (0.21 - 0.24)	0.31 (0.26 - 0.35)	0.53[E] (0.30 - 0.75)
Males, 12–19	2	541	6.10	0.20 (0.17 - 0.23)	0.099 (0.078 - 0.12)	0.20 (0.17 - 0.23)	0.27 (0.21 - 0.33)	0.49[E] (0.27 - 0.71)
Males, 20–39	1	512	11.91	0.26 (0.25 - 0.28)	<LOD	0.25 (0.23 - 0.27)	0.37 (0.34 - 0.40)	0.65 (0.54 - 0.76)
Males, 20–39	2	550	6.55	0.22 (0.19 - 0.26)	0.099 (<LOD - 0.12)	0.22 (0.18 - 0.26)	0.35 (0.28 - 0.42)	0.62 (0.40 - 0.85)
Males, 40–59	1	574	6.62	0.43 (0.39 - 0.48)	0.17 (<LOD - 0.21)	0.42 (0.37 - 0.47)	0.69 (0.59 - 0.80)	1.2 (0.97 - 1.4)
Males, 40–59	2	615	5.37	0.38 (0.33 - 0.44)	0.17 (<LOD - 0.20)	0.37 (0.29 - 0.45)	0.60 (0.46 - 0.75)	1.2 (0.85 - 1.5)
Males, 60–79	1	541	2.22	0.60 (0.53 - 0.68)	0.26 (0.24 - 0.29)	0.56 (0.48 - 0.64)	0.99 (0.75 - 1.2)	1.7 (1.4 - 2.0)
Males, 60–79	2	503	0.99	0.52 (0.45 - 0.61)	0.23 (<LOD - 0.27)	0.49 (0.41 - 0.56)	0.81 (0.60 - 1.0)	1.6 (1.3 - 1.9)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	7.42	0.44 (0.40 - 0.48)	0.16 (0.14 - 0.18)	0.43 (0.38 - 0.47)	0.74 (0.67 - 0.80)	1.9 (1.4 - 2.4)
Females, 6–11	1	509	16.50	0.34 (0.29 - 0.40)	<LOD	0.33 (0.29 - 0.37)	0.47 (0.38 - 0.55)	0.90 (0.68 - 1.1)
Females, 6–11	2	528	11.93	0.27 (0.23 - 0.31)	<LOD	0.27 (0.23 - 0.31)	0.40 (0.31 - 0.48)	0.76 (0.58 - 0.95)
Females, 12–19	1	478	12.97	0.25 (0.22 - 0.27)	<LOD	0.25 (0.23 - 0.27)	0.31 (0.29 - 0.33)	0.53 (0.39 - 0.67)
Females, 12–19	2	498	9.24	0.20 (0.17 - 0.23)	0.097 (<LOD - 0.12)	0.21 (0.18 - 0.23)	0.28 (0.24 - 0.31)	0.44 (0.36 - 0.51)
Females, 20–39	1	653	14.24	0.37 (0.34 - 0.41)	<LOD	0.35 (0.31 - 0.38)	0.55 (0.49 - 0.61)	1.0 (0.77 - 1.3)
Females, 20–39	2	769	7.54	0.34 (0.29 - 0.39)	0.14 (0.12 - 0.16)	0.34 (0.26 - 0.43)	0.51 (0.42 - 0.60)	0.85 (0.76 - 0.95)
Females, 40–59	1	644	8.07	0.67 (0.64 - 0.71)	0.28 (<LOD - 0.33)	0.65 (0.59 - 0.72)	1.0 (0.94 - 1.1)	2.3 (2.1 - 2.5)
Females, 40–59	2	608	3.95	0.59 (0.50 - 0.68)	0.25 (0.20 - 0.29)	0.54 (0.44 - 0.64)	0.94 (0.77 - 1.1)	2.4 (1.7 - 3.0)
Females, 60–79	1	542	4.06	0.81 (0.75 - 0.87)	0.36 (<LOD - 0.39)	0.79 (0.71 - 0.88)	1.2 (0.97 - 1.4)	2.4 (2.0 - 2.8)
Females, 60–79	2	577	2.25	0.76 (0.72 - 0.81)	0.31 (0.24 - 0.38)	0.75 (0.68 - 0.82)	1.1 (1.0 - 1.3)	2.6 (1.9 - 3.2)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

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8.4 CESIUM

Cesium (CASRN 7440-46-2) is a naturally occurring rare alkali metal present in the Earth's crust at an average concentration of approximately 0.0001% (ATSDR, 2004). In its pure form, cesium is a silvery white, soft, and ductile metal. Pure cesium metal is not expected to be found in the environment as it ignites spontaneously in air and reacts vigorously with water to form cesium hydroxide (Ferguson & Gorrie, 2011). There are 11 major radioactive isotopes of cesium, the two most important of which are cesium 134 and cesium 137. In the environment, cesium is naturally present as a stable non-radioactive isotope in various ores and to a lesser extent in soil. Unlike pure cesium, cesium compounds do not react violently in air and are generally very water soluble.

Cesium can be naturally released into the environment through weathering and erosion of cesium-containing minerals (ATSDR, 2004). In addition to natural sources, cesium is released into the atmosphere through human activities such as mining and manufacturing (ATSDR, 2004). Radioactive forms of cesium are produced as by-products during the operation of nuclear power plants and from the use of nuclear weapons (ATSDR, 2004).

Cesium has very few industrial applications. Its principal use is in formate brines used for oil and gas drilling and exploration (IARC, 2001). Cesium compounds are used in research and development, and are used commercially in biomedical, chemical, and electronic applications (USGS, 2012). Radioactive cesium isotopes are used to treat prostate and other cancers, and a number of industries rely on cesium 137 as a component in industrial gauges and for the sterilization of food, sewage, and surgical equipment. Non-radioactive cesium chloride is sometimes used as a natural health product for self-treatment of cancer, although its use as a therapeutic agent is not authorized in Canada (Painter et al., 2008).

In the general population, exposure to cesium can occur via ingestion of food and drinking water, inhalation of ambient air, and dermal contact (ATSDR, 2004). Oral ingestion of food items is the greatest source of internal exposure for both naturally occurring and radioactive cesium (ATSDR, 2004).

Following ingestion, cesium is almost completely absorbed by the intestine. Absorbed cesium undergoes widespread distribution in the body. The majority of absorbed cesium is excreted via urine with a small portion released in feces (ATSDR, 2004). Recent exposure can be evaluated by measuring cesium concentrations in urine (ATSDR, 2004).

Health effects in humans associated with exposure to high levels of stable cesium include nausea, diarrhea, and loss of appetite (Neulieb, 1984). Several reports of cardiac effects have also been associated with repeated oral intake of cesium chloride for unauthorized therapeutic use (Painter et al., 2008). Results from a number of animal studies have shown a relatively low acute toxicity of cesium and its compounds (ATSDR, 2004).

The primary health effects of exposure to radioactive cesium are related to the emission of ionizing radiation, a human carcinogen (IARC, 2001; IARC, 2012). The International Agency for Research on Cancer determined that there is sufficient evidence in laboratory animals to classify the cesium 137 radioisotope as Group 1, carcinogenic to humans (IARC, 2001).

On the basis of health considerations, Health Canada has developed a Canadian drinking water quality guideline that sets out the maximum acceptable concentration of cesium 137 (Health Canada, 2009a; Health Canada, 2012). Health Canada has also calculated maximum acceptable concentrations for cesium 131, cesium 134, and cesium 136 (Health Canada, 2009a). However, because these isotopes are not expected to be found in Canadian drinking water sources, the concentrations represent the theoretical level at which potential health effects could occur and have been calculated for information purposes only (Health Canada, 2009a). Cesium is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009b). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply. In addition, Health Canada has developed cesium radionuclide action levels for various foods (Health Canada, 2000).

Cesium was measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and is presented as both µg/L and µg/g creatinine (Tables 8.4.1, 8.4.2, 8.4.3, and 8.4.4). Finding a measurable amount of cesium in urine is an indicator of exposure to cesium and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary cesium levels in the Canadian population.

Table 8.4.1

Cesium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6395	0	4.9 (4.6 - 5.2)	1.8 (1.6 - 1.9)	5.0 (4.6 - 5.3)	7.4 (6.8 - 8.0)	13 (12 - 14)
3–5	2	601	0	6.6 (5.4 - 8.0)	2.7 (2.1 - 3.3)	5.6 (4.9 - 6.3)	8.0 (6.8 - 9.3)	14[E] (8.7 - 19)
6–11	2	1075	0	5.5 (4.8 - 6.3)	2.4 (2.1 - 2.8)	5.3 (4.8 - 5.8)	7.3 (6.6 - 7.9)	12 (9.3 - 15)
12–19	2	1060	0	5.2 (4.5 - 6.0)	1.8 (1.4 - 2.1)	5.1 (4.5 - 5.6)	7.5 (6.7 - 8.2)	F
20–39	2	1329	0	4.5 (4.1 - 4.9)	1.7 (1.3 - 2.1)	4.8 (4.4 - 5.3)	7.2 (6.4 - 8.0)	12 (9.5 - 14)
40–59	2	1232	0	5.1 (4.5 - 5.8)	1.7 (1.5 - 1.9)	5.2 (4.5 - 5.9)	7.9 (6.8 - 9.1)	14 (10 - 18)
60–79	2	1098	0	4.4 (4.1 - 4.7)	1.7 (1.6 - 1.9)	4.4 (3.9 - 4.8)	6.8 (6.2 - 7.3)	12 (11 - 14)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.4.2

Cesium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	3076	0	5.2 (4.7 - 5.8)	2.0 (1.7 - 2.2)	5.2 (4.8 - 5.6)	7.7 (7.0 - 8.4)	13 (11 - 15)
Males, 6–11	2	534	0	5.3 (4.5 - 6.1)	2.6 (2.3 - 2.9)	5.1 (4.5 - 5.8)	6.9 (6.1 - 7.8)	12 (9.0 - 14)
Males, 12–19	2	550	0	5.6 (4.6 - 6.8)	2.2 (1.7 - 2.7)	5.2 (4.6 - 5.9)	7.5 (6.6 - 8.4)	F
Males, 20–39	2	556	0	4.8 (4.2 - 5.3)	1.8 (1.4 - 2.3)	5.1 (4.6 - 5.7)	7.5 (6.5 - 8.4)	12 (10 - 15)
Males, 40–59	2	619	0	5.6 (4.6 - 6.9)	1.9 (1.4 - 2.4)	5.5 (4.5 - 6.6)	8.5 (6.1 - 11)	16 (12 - 20)
Males, 60–79	2	509	0	4.6 (4.2 - 5.2)	1.9 (1.6 - 2.3)	4.7 (4.2 - 5.2)	7.1 (6.4 - 7.8)	12 (10 - 14)
Females, Total 3–79	2	3319	0	4.6 (4.3 - 4.8)	1.6 (1.4 - 1.7)	4.7 (4.4 - 5.0)	7.1 (6.6 - 7.5)	12 (11 - 13)
Females, 6–11	2	541	0	5.8 (4.8 - 7.0)	2.0 (1.7 - 2.3)	5.4 (4.9 - 5.8)	7.4 (6.5 - 8.3)	13 (9.5 - 16)
Females, 12–19	2	510	0	4.8 (4.2 - 5.4)	1.5 (1.2 - 1.8)	4.7 (4.1 - 5.3)	7.4 (6.6 - 8.2)	11 (9.8 - 13)
Females, 20–39	2	773	0	4.3 (3.8 - 4.9)	1.5 (1.0 - 2.0)	4.5 (4.0 - 5.1)	7.1 (5.9 - 8.2)	11 (8.9 - 12)
Females, 40–59	2	613	0	4.6 (4.1 - 5.1)	1.6 (1.3 - 1.8)	5.0 (4.5 - 5.4)	7.3 (6.3 - 8.3)	13[E] (8.0 - 18)
Females, 60–79	2	589	0	4.2 (3.9 - 4.5)	1.6 (1.3 - 1.8)	3.9 (3.3 - 4.5)	6.4 (5.7 - 7.1)	12 (10 - 14)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.4.3

Cesium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6299	0	4.4 (4.2 - 4.6)	2.5 (2.4 - 2.6)	4.3 (4.1 - 4.6)	5.8 (5.5 - 6.2)	9.9 (9.0 - 11)
3–5	2	572	0	8.9 (8.3 - 9.6)	5.2 (4.5 - 5.8)	8.9 (8.3 - 9.5)	12 (11 - 13)	19 (16 - 22)
6–11	2	1059	0	5.6 (5.3 - 6.0)	3.3 (3.1 - 3.5)	5.4 (5.0 - 5.9)	7.4 (6.8 - 7.9)	11 (10 - 12)
12–19	2	1042	0	3.5 (3.4 - 3.7)	2.1 (2.0 - 2.2)	3.4 (3.3 - 3.6)	4.6 (4.4 - 4.8)	6.7 (<LOD - 7.5)
20–39	2	1322	0	3.7 (3.5 - 3.9)	2.3 (2.1 - 2.4)	3.5 (3.2 - 3.7)	4.8 (4.4 - 5.2)	7.1 (6.0 - 8.3)
40–59	2	1223	0	4.7 (4.3 - 5.0)	2.7 (2.5 - 2.9)	4.6 (4.2 - 5.0)	6.1 (5.6 - 6.6)	9.8 (7.7 - 12)
60–79	2	1081	0	5.0 (4.7 - 5.2)	2.8 (2.5 - 3.0)	5.0 (4.8 - 5.1)	6.5 (6.1 - 6.9)	11 (10 - 12)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.4.4

Cesium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	3031	0	4.0 (3.8 - 4.2)	2.3 (2.2 - 2.4)	3.8 (3.6 - 4.1)	5.3 (5.0 - 5.6)	9.0 (7.9 - 10)
Males, 6–11	2	530	0	5.5 (5.1 - 6.0)	3.2 (2.9 - 3.5)	5.3 (4.8 - 5.9)	7.6 (7.0 - 8.2)	11 (10 - 12)
Males, 12–19	2	542	0	3.3 (3.1 - 3.6)	1.9 (1.7 - 2.1)	3.3 (3.0 - 3.5)	4.5 (4.1 - 4.8)	7.1 (<LOD - 9.0)
Males, 20–39	2	551	0	3.2 (3.1 - 3.4)	2.1 (1.7 - 2.4)	3.2 (3.0 - 3.4)	4.1 (3.8 - 4.4)	5.6 (5.3 - 5.9)
Males, 40–59	2	615	0	4.2 (3.8 - 4.6)	2.6 (2.2 - 2.9)	4.1 (3.7 - 4.6)	5.6 (5.0 - 6.1)	8.2 (6.0 - 10)
Males, 60–79	2	504	0	4.4 (4.1 - 4.7)	2.6 (2.4 - 2.8)	4.5 (4.2 - 4.7)	5.6 (5.0 - 6.2)	8.6 (7.2 - 10)
Females, Total 3–79	2	3268	0	4.9 (4.6 - 5.2)	2.7 (2.5 - 2.9)	4.7 (4.4 - 5.0)	6.4 (5.9 - 6.8)	11 (9.6 - 13)
Females, 6–11	2	529	0	5.7 (5.3 - 6.1)	3.6 (3.3 - 3.8)	5.5 (4.9 - 6.1)	7.0 (6.5 - 7.5)	11 (9.7 - 12)
Females, 12–19	2	500	0	3.7 (3.5 - 4.0)	2.2 (2.0 - 2.5)	3.5 (3.3 - 3.8)	4.7 (4.5 - 4.9)	6.5 (5.8 - 7.2)
Females, 20–39	2	771	0	4.2 (3.9 - 4.5)	2.5 (2.2 - 2.8)	4.0 (3.7 - 4.4)	5.2 (4.7 - 5.6)	8.2 (7.2 - 9.2)
Females, 40–59	2	608	0	5.2 (4.7 - 5.7)	3.0 (2.8 - 3.2)	5.0 (4.5 - 5.4)	6.7 (5.9 - 7.6)	12 (8.0 - 15)
Females, 60–79	2	577	0	5.6 (5.2 - 5.9)	3.1 (2.6 - 3.6)	5.5 (5.2 - 5.8)	7.2 (6.8 - 7.6)	12 (11 - 13)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.5 COBALT

Elemental cobalt (CASRN 7440-48-4) is a hard, silvery grey metal with magnetic properties. It is present in the Earth's crust at an average concentration of approximately 0.0025%, and occurs naturally in various mineral forms (ATSDR, 2004). Cobalt minerals occur in nature in other metal deposits (particularly copper and nickel) generally as sulfides, oxides, or arsenides (IARC, 1991). It has several radioisotopes, two of which are commercially important: cobalt 57 and cobalt 60. Cobalt is an essential trace element required for the maintenance of good health in humans.

Cobalt is naturally released into the environment through leaching from soil, airborne dust, sea spray, volcanic eruptions, and forest fires (ATSDR, 2004). Significant quantities of cobalt are also released as by-products of the mining industry. Other anthropogenic sources of cobalt include burning of fossil fuels, smelting and refining of cobalt ores, and processing of cobalt alloys (ATSDR, 2004).

In Canada, cobalt is primarily used in industrial raw materials (Environment Canada & Health Canada, 2011). Elemental cobalt is a component in alloys that are used to manufacture gas turbines for aircraft engines and hard metals for tools. Cobalt is also used to manufacture pigments and fertilizers and as a drying agent in paint, varnishes, and inks. Cobalt compounds are used as catalysts in oil and gas refining and in the synthesis of polyester and other materials. They are also used in the manufacture of battery electrodes, steel-belted radial tires, car airbags, diamond polishing wheels, and magnetic recording media. Cobalt 60 is used as a source of gamma rays for food irradiation, sterilization of medical and consumer products, and radiation treatment of cancer, whereas the use of cobalt 57 is limited to medical and scientific research (ATSDR, 2004; Richardson, 2003).

Cobalt exposure in the general population occurs primarily through food and to a lesser degree through drinking water and air (ATSDR, 2004). Soluble cobalt compounds are absorbed via oral or pulmonary routes. Absorption of cobalt via the gastrointestinal tract varies considerably (18% to 97% of the given dose), based on the type and dose of cobalt compound and the nutritional status of the subjects (ATSDR, 2004). The majority of absorbed cobalt is excreted through urine within several days. However, a small amount of the element may be retained in the body with a biological half-life varying between 2 and 15 years (IARC, 2006). As a component of vitamin B_{12}, cobalt is found in most body tissues with the highest concentrations observed in the liver (ATSDR, 2004). Urinary cobalt can be used as a biomarker of recent exposure to soluble cobalt compounds (CDC, 2009).

As an essential trace element, cobalt has a functional role in vitamin B_{12}; this vitamin helps the body form red blood cells and metabolize carbohydrates, fats, and proteins. Vitamin B_{12} deficiency results in the development of pernicious anemia. The cobalt in vitamin B_{12} does not exchange with cobalt in the blood and no other essential functions for cobalt are known. On account of its essentiality, Health Canada has recommended minimum and maximum daily intake levels of cobalt in the form of vitamin B_{12} (Health Canada, 2007).

Adverse health effects have been traced to elevated levels of cobalt compounds from non-occupational exposures. Cobalt sulphate and cobalt chloride were used in the 1950s and 1960s in the United States, Canada, and Europe as a foam stabilizer in beer. During that time, several cases of lethal cardiomyopathy were documented in heavy beer drinkers (Alexander, 1972). Altered thyroid function associated with cardiomyopathy has also been observed following cobalt exposure over a period of a few weeks (ATSDR, 2004; Roy et al., 1968).

Several cancer studies for workers in hard-metal production facilities provide evidence of an increased lung cancer risk related to exposure to hard-metal dust containing cobalt and tungsten carbide (IARC, 2006; IPCS, 2006). In 1991, the International Agency for Research on Cancer (IARC) has classified cobalt and its compounds as Group 2B, possibly carcinogenic to humans, based on inadequate evidence linking exposure and lung cancer in humans but with limited or sufficient evidence in animals for some specific cobalt compounds (IARC, 1991). In 2006, IARC evaluated the exposure of cobalt metal with tungsten carbide as Group 2A, probably carcinogenic to humans (IARC, 2006). Cobalt metal without tungsten carbide as well as cobalt salts were also re-evaluated in 2006 and continue to be classified as Group 2B, based on inadequate evidence of carcinogenicity in humans (IARC, 2006).

As part of the Chemicals Management Plan under the *Canadian Environmental Protection Act, 1999*, elemental cobalt, cobalt chloride, and cobalt sulphate were identified as high-priority substances; the final screening assessment was published in 2011 (Canada, 1999; Environment Canada & Health Canada, 2011). The assessment concluded that levels of cobalt normally found in the Canadian environment are not considered harmful to human health (Environment Canada & Health Canada, 2011). This assessment is the starting point for an assessment of all sources of environmental cobalt that is currently in preparation as part of the Chemicals Management Plan; a draft assessment is expected to be published in 2014.

Radioactive isotopes of cobalt are used by industry and in research. These radionuclides are not expected to be found in Canadian drinking water sources, and exposure to the general public is limited to rare cases of accidental loss, theft, or damage of contained sources (Health Canada, 2009a; IARC, 2012). The health effects of exposure to radioactive cobalt are related to the emission of ionizing radiation, a human carcinogen (IARC, 2012).

Health Canada has developed Canadian drinking water quality guidelines that set out the maximum acceptable concentrations of cobalt 57 and cobalt 60. Because these isotopes are not expected to be found in Canadian drinking water sources, the concentrations represent the theoretical level at which potential health effects could occur and have been calculated for information purposes only (Health Canada, 2009a). Cobalt is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009b). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply. In addition, Health Canada has developed cobalt radionuclide action levels for various foods (Health Canada, 2000).

In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric means for cobalt in urine and whole blood were below the detection limits of 0.35 µg/L and 0.18 µg/L, respectively (INSPQ, 2004).

Cobalt was measured in the whole blood and urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and is presented in blood as µg/L (Tables 8.5.1 and 8.5.2) and in urine as both µg/L and µg/g creatinine (Tables 8.5.3, 8.5.4, 8.5.5, and 8.5.6). Finding a measurable amount of cobalt in blood or urine is an indicator of exposure to cobalt and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for blood and urinary cobalt in the Canadian population.

Table 8.5.1

Cobalt — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6070	0.02	0.23 (0.21 - 0.24)	0.15 (0.13 - 0.17)	0.22 (0.20 - 0.24)	0.27 (0.25 - 0.29)	0.40 (0.36 - 0.43)
3–5	2	495	0	0.26 (0.23 - 0.28)	0.17 (0.13 - 0.21)	0.26 (0.24 - 0.28)	0.31 (0.29 - 0.33)	0.42 (0.32 - 0.52)
6–11	2	961	0	0.25 (0.23 - 0.27)	0.18 (0.16 - 0.20)	0.24 (0.22 - 0.26)	0.29 (0.27 - 0.31)	0.37 (0.34 - 0.40)
12–19	2	997	0.10	0.23 (0.21 - 0.25)	0.16 (0.14 - 0.18)	0.23 (0.21 - 0.25)	0.27 (0.25 - 0.30)	0.38 (0.34 - 0.41)
20–39	2	1313	0	0.22 (0.20 - 0.24)	0.14 (0.12 - 0.16)	0.21 (0.19 - 0.23)	0.27 (0.24 - 0.30)	0.40 (0.35 - 0.44)
40–59	2	1222	0	0.22 (0.21 - 0.24)	0.14 (0.12 - 0.16)	0.21 (0.20 - 0.23)	0.26 (0.24 - 0.28)	0.43 (0.34 - 0.52)
60–79	2	1082	0	0.22 (0.20 - 0.24)	0.14 (0.12 - 0.16)	0.22 (0.20 - 0.24)	0.26 (0.24 - 0.29)	0.39 (0.35 - 0.42)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.5.2

Cobalt — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	2940	0.03	0.21 (0.19 - 0.23)	0.14 (0.12 - 0.16)	0.21 (0.19 - 0.22)	0.25 (0.23 - 0.27)	0.33 (0.30 - 0.37)
Males, 6–11	2	488	0	0.24 (0.23 - 0.27)	0.18 (0.17 - 0.20)	0.24 (0.22 - 0.26)	0.29 (0.26 - 0.31)	0.39 (0.34 - 0.43)
Males, 12–19	2	523	0.19	0.22 (0.20 - 0.24)	0.15 (0.13 - 0.17)	0.22 (0.19 - 0.24)	0.26 (0.23 - 0.29)	0.36 (0.32 - 0.40)
Males, 20–39	2	552	0	0.20 (0.19 - 0.22)	0.14 (0.12 - 0.17)	0.20 (0.18 - 0.22)	0.24 (0.21 - 0.27)	0.29 (0.27 - 0.32)
Males, 40–59	2	617	0	0.20 (0.19 - 0.22)	0.13 (0.11 - 0.15)	0.20 (0.18 - 0.22)	0.24 (0.22 - 0.26)	0.30 (0.27 - 0.33)
Males, 60–79	2	507	0	0.21 (0.20 - 0.23)	0.14 (0.12 - 0.16)	0.21 (0.19 - 0.23)	0.26 (0.23 - 0.28)	0.40 (0.33 - 0.47)
Females, Total 3–79	2	3130	0	0.24 (0.22 - 0.26)	0.15 (0.14 - 0.17)	0.23 (0.21 - 0.26)	0.29 (0.27 - 0.31)	0.44 (0.38 - 0.50)
Females, 6–11	2	473	0	0.25 (0.23 - 0.27)	0.17 (0.14 - 0.20)	0.25 (0.22 - 0.27)	0.30 (0.27 - 0.33)	0.37 (0.34 - 0.39)
Females, 12–19	2	474	0	0.25 (0.23 - 0.27)	0.17 (0.15 - 0.19)	0.25 (0.23 - 0.26)	0.29 (0.26 - 0.31)	0.39 (0.34 - 0.44)
Females, 20–39	2	761	0	0.24 (0.21 - 0.27)	0.15 (0.13 - 0.17)	0.23 (0.20 - 0.27)	0.30 (0.27 - 0.33)	0.45 (0.36 - 0.53)
Females, 40–59	2	605	0	0.24 (0.23 - 0.26)	0.16 (0.14 - 0.18)	0.23 (0.22 - 0.25)	0.29 (0.26 - 0.31)	0.51 (0.41 - 0.62)
Females, 60–79	2	575	0	0.23 (0.21 - 0.25)	0.15 (0.13 - 0.16)	0.22 (0.20 - 0.24)	0.28 (0.24 - 0.31)	0.38 (0.35 - 0.42)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.5.3

Cobalt — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6304	6.87	0.23 (0.21 - 0.26)	<LOD	0.25 (0.22 - 0.29)	0.44 (0.40 - 0.49)	0.97 (0.86 - 1.1)
3–5	2	573	2.79	0.34 (0.30 - 0.39)	0.10 (0.068 - 0.13)	0.37 (0.31 - 0.43)	0.55 (0.48 - 0.63)	1.1E (0.65 - 1.6)
6–11	2	1061	1.60	0.38 (0.35 - 0.41)	0.12 (0.098 - 0.14)	0.40 (0.37 - 0.43)	0.58 (0.53 - 0.64)	1.1 (0.95 - 1.3)
12–19	2	1041	3.17	0.36 (0.32 - 0.41)	0.086 (<LOD - 0.11)	0.36 (0.32 - 0.41)	0.62 (0.54 - 0.71)	1.5 (1.2 - 1.9)
20–39	2	1320	7.80	0.24 (0.20 - 0.27)	<LOD	0.26 (0.21 - 0.30)	0.45 (0.37 - 0.52)	0.92 (0.75 - 1.1)
40–59	2	1224	11.11	0.20 (0.17 - 0.23)	<LOD	0.22 (0.17 - 0.27)	0.41 (0.36 - 0.46)	0.85 (0.72 - 0.97)
60–79	2	1085	11.80	0.18 (0.15 - 0.21)	<LOD	0.18 (0.14 - 0.23)	0.32 (0.26 - 0.38)	0.74 (0.51 - 0.98)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.5.4

Cobalt — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	3035	7.35	0.21 (0.19 - 0.24)	<LOD	0.23 (0.19 - 0.28)	0.41 (0.35 - 0.46)	0.81 (0.71 - 0.91)
Males, 6–11	2	532	1.50	0.39 (0.35 - 0.44)	0.13 (0.087 - 0.18)	0.42 (0.37 - 0.46)	0.59 (0.48 - 0.69)	1.0 (0.72 - 1.3)
Males, 12–19	2	542	3.51	0.34 (0.29 - 0.40)	0.091[E] (<LOD - 0.13)	0.36 (0.30 - 0.42)	0.55 (0.47 - 0.64)	1.2 (0.86 - 1.5)
Males, 20–39	2	551	10.34	0.19 (0.16 - 0.23)	<LOD	0.20 (0.16 - 0.25)	0.35 (0.27 - 0.43)	0.69 (0.55 - 0.82)
Males, 40–50	2	615	11.87	0.18 (0.15 - 0.22)	<LOD	0.20 (0.14 - 0.26)	0.34 (0.27 - 0.40)	0.60 (0.49 - 0.71)
Males, 60–79	2	505	11.09	0.18 (0.16 - 0.21)	<LOD	0.18 (0.14 - 0.23)	0.33 (0.27 - 0.38)	0.70[E] (0.45 - 0.96)
Females, Total 3–79	2	3269	6.42	0.25 (0.23 - 0.28)	<LOD	0.27 (0.24 - 0.30)	0.52 (0.46 - 0.57)	1.1 (1.0 - 1.3)
Females, 6–11	2	529	1.70	0.36 (0.33 - 0.40)	0.11 (0.084 - 0.14)	0.37 (0.33 - 0.41)	0.57 (0.49 - 0.66)	1.2 (1.0 - 1.3)
Females, 12–19	2	499	2.81	0.38 (0.32 - 0.45)	0.080[E] (<LOD - 0.12)	0.37 (0.31 - 0.44)	0.73 (0.64 - 0.83)	1.8[E] (1.1 - 2.6)
Females, 20–39	2	769	5.98	0.29 (0.24 - 0.35)	<LOD[E] (<LOD - 0.078)	0.33 (0.26 - 0.39)	0.58 (0.47 - 0.69)	1.2 (0.97 - 1.3)
Females, 40–59	2	609	10.34	0.22 (0.19 - 0.26)	<LOD	0.24 (0.19 - 0.29)	0.50 (0.39 - 0.61)	0.99 (0.64 - 1.4)
Females, 60–79	2	580	12.41	0.17 (0.14 - 0.21)	<LOD	0.18 (0.13 - 0.23)	0.31 (0.23 - 0.39)	0.76[E] (0.41 - 1.1)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.5.5

Cobalt (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6285	6.89	0.22 (0.20 - 0.25)	<LOD	0.22 (0.19 - 0.24)	0.38 (0.34 - 0.41)	0.88 (0.79 - 0.97)
3–5	2	572	2.80	0.59 (0.52 - 0.66)	0.30 (0.25 - 0.36)	0.60 (0.54 - 0.66)	0.78 (0.60 - 0.97)	1.5 (1.2 - 1.7)
6–11	2	1057	1.61	0.43 (0.40 - 0.46)	0.23 (0.21 - 0.26)	0.43 (0.40 - 0.46)	0.59 (0.54 - 0.64)	1.1 (0.91 - 1.3)
12–19	2	1039	3.18	0.27 (0.25 - 0.30)	0.11 (<LOD - 0.13)	0.26 (0.24 - 0.29)	0.43 (0.39 - 0.46)	0.91 (0.77 - 1.1)
20–39	2	1318	7.81	0.20 (0.17 - 0.22)	<LOD	0.19 (0.16 - 0.22)	0.32 (0.27 - 0.38)	0.77 (0.58 - 0.96)
40–59	2	1220	11.15	0.19 (0.17 - 0.22)	<LOD	0.19 (0.16 - 0.22)	0.30 (0.26 - 0.34)	0.82 (0.67 - 0.97)
60–79	2	1079	11.86	0.21 (0.18 - 0.24)	<LOD	0.21 (0.18 - 0.23)	0.32 (0.26 - 0.38)	0.76 (0.57 - 0.94)

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.5.6

Cobalt (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	3028	7.36	0.17 (0.16 - 0.20)	<LOD	0.17 (0.14 - 0.19)	0.28 (0.24 - 0.31)	0.68 (0.61 - 0.75)
Males, 6–11	2	530	1.51	0.43 (0.38 - 0.49)	0.23 (0.21 - 0.26)	0.44 (0.39 - 0.50)	0.60 (0.54 - 0.66)	1.1 (0.81 - 1.5)
Males, 12–19	2	541	3.51	0.23 (0.21 - 0.26)	0.11 (<LOD - 0.13)	0.23 (0.20 - 0.26)	0.37 (0.33 - 0.42)	0.75 (0.58 - 0.92)
Males, 20–39	2	550	10.36	0.14 (0.11 - 0.16)	<LOD	0.13 (0.11 - 0.16)	0.20 (0.15 - 0.26)	0.37 (0.29 - 0.46)
Males, 40–59	2	615	11.87	0.14 (0.13 - 0.17)	<LOD	0.15 (0.13 - 0.17)	0.21 (0.19 - 0.24)	0.43 (0.35 - 0.51)
Males, 60–79	2	503	11.13	0.18 (0.16 - 0.20)	<LOD	0.18 (0.15 - 0.20)	0.27 (0.23 - 0.30)	0.65 (0.48 - 0.81)
Females, Total 3–79	2	3257	6.45	0.28 (0.25 - 0.32)	<LOD	0.28 (0.25 - 0.31)	0.46 (0.41 - 0.52)	0.98 (0.85 - 1.1)
Females, 6–11	2	527	1.71	0.43 (0.39 - 0.46)	0.23 (0.20 - 0.26)	0.42 (0.38 - 0.46)	0.56 (0.48 - 0.65)	1.0 (0.85 - 1.2)
Females, 12–19	2	498	2.81	0.32 (0.28 - 0.36)	0.13 (<LOD - 0.15)	0.31 (0.27 - 0.35)	0.49 (0.42 - 0.55)	1.1 (0.78 - 1.5)
Females, 20–39	2	768	5.99	0.28 (0.25 - 0.32)	<LOD (<LOD - 0.15)	0.27 (0.21 - 0.32)	0.47 (0.37 - 0.56)	0.89 (0.78 - 1.0)
Females, 40–59	2	605	10.41	0.26 (0.22 - 0.30)	<LOD	0.26 (0.21 - 0.31)	0.41 (0.32 - 0.50)	0.92 (0.67 - 1.2)
Females, 60–79	2	576	12.50	0.24 (0.20 - 0.29)	<LOD	0.23 (0.20 - 0.26)	0.37 (0.29 - 0.45)	0.78 (0.56 - 1.0)

[a] Breakdown by sex for the 3–5 year old age group is not recommended.

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.6 COPPER

Copper (CASRN 7440-50-8) is a base metal present in the Earth's crust at an average concentration of approximately 0.005% (ATSDR, 2004). Pure copper is a reddish, lustrous, malleable, and ductile metal, whereas many copper compounds have a blue-green colour (CCME, 1999). Copper is an essential trace element required for the maintenance of good health in humans.

Copper occurs naturally in rock, soil, sediment, water, plants, and animals (CCME, 1999). It is released from natural sources including volcanoes, decaying vegetation, and forest fires (ATSDR, 2004). It is also released from anthropogenic sources such as mining, farming, manufacturing operations, and combustion of fuels and other copper-containing materials.

Copper is mined extensively for use in the manufacture of brass, bronze, gunmetal, and nickel alloys (ATSDR, 2004). Copper alloys are used in sheet metal, piping, and electrical conductors. Copper and copper alloys are also used in cooking utensils, coins, anti-fouling paint, dental amalgams, plumbing fixtures and pipes, and architectural applications such as roofing, guttering, and flashing. In addition, copper compounds are important chemicals in the textile, petroleum refining, wood preservative, and agricultural industries (ATSDR, 2004; CCME, 1999; IPCS, 1998).

For the general population, most exposure to copper originates from the ingestion of food (ATSDR, 2004). Additional exposure may result from inhalation of dust particles and ingestion of drinking water (CCME, 1999).

Approximately 24% to 60% of copper is absorbed following oral ingestion; absorption is affected by a number of factors, including age, the amount of copper in the diet, and the presence of other metals (ATSDR, 2004; IPCS, 1998). Following ingestion, absorbed copper is bound to plasma protein carriers and transported to the liver. Copper is then redistributed from the liver to other tissues where it is stored bound to metallothionein and amino acids (ATSDR, 2004). Elimination of copper is biphasic with a biological half-life in the plasma of 2.5 and 69 days for the first and second phases, respectively (ATSDR, 2004). Bile is the major excretory route for copper; up to 70% of orally ingested copper may be excreted in the feces. Normally 0.5% to 3.0% of daily copper intake is excreted in the urine (ATSDR, 2004). Exposure to copper can lead to increased copper concentrations in whole blood, serum, urine, feces, hair, and the liver. Concentrations in serum have been observed to decrease rapidly after exposure, indicating that they may reflect only recent exposures (ATSDR, 2004).

As an essential trace element, copper is required for growth and proper functioning of many physiological processes, including cellular respiration, iron metabolism, antioxidant defence, connective tissue development, and neurotransmitter production (IPCS, 1998). Overt copper deficiency is relatively rare, but has been associated with effects such as anaemia, neutropenia, and bone abnormalities (IPCS, 1998).

High doses of copper may result in adverse effects, although chronic and acute toxic effects from copper are rare in the general population (ATSDR, 2004). Hemodialysis patients, individuals with the genetic disorder Wilson's disease, and those with chronic liver disease may be more susceptible to copper toxicity (IPCS, 1998). High copper intake can result in liver damage; however, this is observed almost exclusively in patients with Wilson's disease and in children with Indian childhood cirrhosis and idiopathic copper toxicosis (IOM, 2001). Acute oral exposure to copper has been associated with nausea, vomiting, and diarrhea (ATSDR, 2004; Olivares et al., 2001). When inhaled, copper is a respiratory tract irritant (ATSDR, 2004).

The International Agency for Research on Cancer has not reviewed copper for its carcinogenic potential (ITER, 2010). The United States Environmental Protection Agency has concluded that human and animal data were inadequate to assess the carcinogenicity of copper and copper compounds (EPA, 1988).

Maximum levels for copper in dietary supplement formulations (tablets, capsules, etc.) have been established in Canada (Health Canada, 2007). The sale and use of copper-containing pesticides is regulated in Canada by the Pest Management Regulatory Agency (PMRA) under the *Pest Control Products Act* (Canada, 2006). In 2009, PMRA initiated a re-evaluation of a number of copper-based active ingredients in pesticide products with agricultural or antimicrobial uses (Health Canada, 2009a). Based on this re-evaluation, PMRA has proposed to conclude that pesticides containing these forms of copper do not present unacceptable risks to human health when used according to label directions and provided that risk-reduction measures are implemented (Health Canada, 2009a).

Tolerable upper intake levels for copper, based on liver damage as the critical adverse effect, have been developed by the Institute of Medicine and adopted by Health Canada (Health Canada, 2010; IOM, 2001). Health Canada has also established an aesthetic objective for copper in drinking water, based on palatability and staining of laundry and plumbing fixtures (Health Canada, 1992). This guideline was deemed protective of adverse health effects, but a health-based value has not been established (Health Canada, 1992). Copper is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009b). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply.

In a study carried out in British Columbia to assess the levels of trace elements in 61 non-smoking adults aged 30 to 65 years, the geometric mean and 95th percentile values of copper in urine were 10.67 µg/g creatinine and 19.66 µg/g creatinine, respectively (Clark et al., 2007).

Copper was measured in the whole blood and urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented in blood as µg/L (Tables 8.6.1, 8.6.2, and 8.6.3) and in urine as both µg/L (Tables 8.6.4, 8.6.5, and 8.6.6) and µg/g creatinine (Tables 8.6.7, 8.6.8, and 8.6.9). Finding a measurable amount of copper in blood or urine is an indicator of exposure to copper and does not necessarily mean that an adverse health effect will occur. Because copper is an essential trace element, its presence in biological fluids is expected.

Table 8.6.1

Copper — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5318	0	910 (900 - 930)	750 (740 - 760)	890 (870 - 900)	990 (980 - 1000)	1200 (1200 - 1300)
Total, 6–79	2	5575	0	900 (890 - 910)	710 (700 - 720)	850 (840 - 860)	950 (940 - 960)	1200 (1200 - 1300)
Males, Total 6–79	1	2575	0	850 (840 - 870)	720 (710 - 740)	840 (830 - 860)	910 (890 - 930)	1000 (980 - 1100)
Males, Total 6–79	2	2687	0	830 (820 - 850)	680 (670 - 690)	800 (780 - 810)	870 (860 - 890)	1000 (990 - 1000)
Females, Total 6–79	1	2743	0	980 (970 - 1000)	800 (780 - 820)	960 (940 - 970)	1000 (1000 - 1100)	1400 (1300 - 1400)
Females, Total 6–79	2	2888	0	970 (960 - 980)	770 (760 - 780)	920 (910 - 930)	1000 (1000 - 1000)	1300 (1300 - 1400)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.6.2

Copper — Geometric means and selected percentiles of whole blood concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6070	0	900 (900 - 910)	710 (700 - 720)	860 (850 - 860)	960 (950 - 970)	1200 (1200 - 1300)
3–5[b]	1							
3–5	2	495	0	1000 (1000 - 1100)	860 (830 - 890)	1000 (970 - 1000)	1100 (1100 - 1200)	1300 (1200 - 1300)
6–11	1	909	0	970 (950 - 1000)	820 (790 - 860)	970 (950 - 980)	1000 (980 - 1000)	1200 (1100 - 1200)
6–11	2	961	0	980 (960 - 990)	800 (780 - 820)	930 (920 - 950)	1000 (1000 - 1100)	1200 (1100 - 1300)
12–19	1	945	0	900 (870 - 920)	720 (700 - 750)	860 (840 - 870)	970 (930 - 1000)	1300 (1100 - 1500)
12–19	2	997	0	880 (860 - 890)	680 (660 - 700)	810 (800 - 830)	920 (910 - 940)	1400 (1300 - 1400)
20–39	1	1165	0	920 (900 - 940)	730 (710 - 750)	870 (840 - 890)	990 (980 - 1000)	1400 (1300 - 1500)
20–39	2	1313	0	890 (880 - 910)	700 (680 - 720)	820 (810 - 840)	940 (920 - 960)	1300 (1200 - 1400)
40–59	1	1220	0	900 (890 - 920)	760 (740 - 770)	890 (870 - 900)	980 (960 - 1000)	1100 (1100 - 1200)
40–59	2	1222	0	900 (880 - 910)	720 (710 - 730)	860 (840 - 880)	950 (930 - 960)	1100 (1100 - 1100)
60–79	1	1079	0	920 (900 - 930)	770 (750 - 790)	900 (880 - 920)	990 (980 - 1000)	1100 (1100 - 1200)
60–79	2	1082	0	900 (890 - 920)	720 (710 - 730)	860 (850 - 880)	960 (940 - 970)	1100 (1100 - 1200)

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[b] Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.6.3

Copper — Geometric means and selected percentiles of whole blood concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2940	0	840 (830 - 850)	680 (670 - 690)	800 (790 - 810)	880 (870 - 890)	1000 (1000 - 1100)
Males, 6–11	1	458	0	1000 (970 - 1000)	850 (820 - 870)	990 (980 - 1000)	1000 (1000 - 1100)	1200 (1100 - 1300)
Males, 6–11	2	488	0	1000 (980 - 1000)	830 (800 - 850)	960 (930 - 1000)	1100 (1000 - 1100)	1200 (1200 - 1300)
Males, 12–19	1	489	0	830 (820 - 850)	700 (680 - 730)	820 (800 - 840)	890 (870 - 920)	1000 (990 - 1100)
Males, 12–19	2	523	0	810 (790 - 830)	650 (630 - 680)	770 (750 - 790)	850 (820 - 890)	960 (930 - 1000)
Males, 20–39	1	514	0	820 (800 - 840)	700 (680 - 730)	820 (800 - 840)	880 (860 - 910)	990 (950 - 1000)
Males, 20–39	2	552	0	810 (790 - 820)	670 (660 - 690)	770 (750 - 790)	830 (810 - 850)	930 (900 - 960)
Males, 40–59	1	577	0	850 (830 - 870)	730 (710 - 760)	850 (830 - 860)	900 (880 - 910)	1000 (990 - 1000)
Males, 40–59	2	617	0	840 (820 - 860)	690 (660 - 710)	800 (780 - 820)	880 (850 - 910)	990 (950 - 1000)
Males, 60–79	1	537	0	860 (850 - 880)	740 (730 - 750)	860 (840 - 880)	920 (890 - 940)	1000 (950 - 1100)
Males, 60–79	2	507	0	840 (830 - 850)	690 (670 - 710)	810 (790 - 820)	870 (860 - 890)	1000 (970 - 1000)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3130	0	970 (960 - 980)	770 (760 - 780)	920 (910 - 930)	1000 (1000 - 1000)	1300 (1300 - 1400)
Females, 6–11	1	451	0	950 (930 - 980)	790 (750 - 830)	960 (940 - 980)	1000 (980 - 1000)	1200 (1100 - 1200)
Females, 6–11	2	473	0	950 (930 - 970)	780 (770 - 800)	910 (890 - 930)	990 (960 - 1000)	1200 (1000 - 1300)
Females, 12–19	1	456	0	970 (930 - 1000)	750 (740 - 770)	920 (890 - 950)	1100 (980 - 1200)	1600 (1400 - 1700)
Females, 12–19	2	474	0	960 (930 - 980)	710 (700 - 730)	870 (850 - 900)	1100 (1000 - 1100)	1500 (1400 - 1600)
Females, 20–39	1	651	0	1000 (1000 - 1100)	800 (760 - 840)	980 (960 - 1000)	1100 (1100 - 1200)	1600 (1400 - 1700)
Females, 20–39	2	761	0	990 (960 - 1000)	760 (750 - 780)	920 (890 - 950)	1100 (970 - 1200)	1500 (1300 - 1600)
Females, 40–59	1	643	0	960 (940 - 980)	800 (770 - 840)	950 (930 - 970)	1000 (970 - 1000)	1200 (1100 - 1200)
Females, 40–59	2	605	0	960 (940 - 970)	780 (770 - 800)	920 (900 - 940)	1000 (990 - 1000)	1200 (1100 - 1200)
Females, 60–79	1	542	0	970 (950 - 990)	820 (800 - 830)	960 (940 - 970)	1000 (980 - 1000)	1200 (1100 - 1300)
Females, 60–79	2	575	0	970 (950 - 1000)	790 (770 - 800)	930 (910 - 950)	1000 (990 - 1000)	1200 (1100 - 1400)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.6.4

Copper — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5492	0.29	9.0 (8.2 - 9.8)	3.0 (2.5 - 3.5)	9.9 (9.5 - 10)	15 (14 - 16)	26 (25 - 28)
Total, 6–79	2	5738	0.19	11 (10 - 11)	4.0 (3.6 - 4.4)	12 (11 - 13)	17 (17 - 18)	28 (26 - 29)
Males, Total 6–79	1	2662	0.23	10 (9.3 - 11)	3.8 (3.1 - 4.5)	11 (10 - 12)	16 (15 - 17)	27 (25 - 29)
Males, Total 6–79	2	2746	0.18	12 (11 - 12)	4.7 (4.3 - 5.1)	13 (12 - 13)	18 (17 - 19)	28 (25 - 30)
Females, Total 6–79	1	2830	0.35	8.0 (7.3 - 8.9)	2.9 (2.4 - 3.3)	8.8 (8.0 - 9.7)	14 (13 - 15)	25 (23 - 27)
Females, Total 6–79	2	2992	0.20	10 (9.6 - 11)	3.7 (3.2 - 4.1)	11 (11 - 12)	17 (16 - 17)	28 (26 - 29)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.6.5

Copper — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6311	0.21	11 (10 - 11)	4.1 (3.7 - 4.5)	12 (11 - 13)	17 (17 - 18)	28 (27 - 29)
3–5[b]	1							
3–5	2	573	0.35	12 (12 - 13)	5.8 (5.2 - 6.3)	13 (12 - 14)	18 (16 - 20)	28 (24 - 31)
6–11	1	1034	0.29	10 (9.4 - 12)	3.8 (2.9 - 4.6)	12 (10 - 13)	17 (16 - 18)	27 (25 - 29)
6–11	2	1062	0	13 (12 - 14)	6.0 (5.4 - 6.6)	13 (13 - 14)	18 (17 - 19)	26 (24 - 28)
12–19	1	983	0.31	12 (11 - 14)	4.4 (3.1 - 5.6)	13 (13 - 14)	19 (18 - 20)	32 (30 - 35)
12–19	2	1041	0.10	13 (12 - 14)	5.6 (4.7 - 6.5)	14 (13 - 15)	19 (18 - 20)	31 (28 - 34)
20–39	1	1169	0.43	8.6 (7.5 - 9.8)	3.0 (2.3 - 3.7)	9.5 (8.5 - 10)	15 (14 - 16)	25 (23 - 28)
20–39	2	1321	0.30	11 (10 - 12)	4.1 (3.2 - 5.0)	12 (11 - 13)	18 (17 - 19)	29 (26 - 32)
40–59	1	1223	0.41	8.1 (7.4 - 9.0)	2.8 (2.0 - 3.6)	9.2 (8.4 - 9.9)	14 (13 - 15)	24 (22 - 26)
40–59	2	1228	0.41	10 (9.5 - 11)	3.7 (3.2 - 4.1)	11 (10 - 12)	17 (15 - 18)	27 (25 - 29)
60–79	1	1083	0	9.0 (8.4 - 9.7)	3.4 (2.9 - 4.0)	9.8 (9.2 - 10)	14 (13 - 15)	24 (21 - 27)
60–79	2	1086	0.09	9.9 (9.4 - 11)	3.7 (3.4 - 4.0)	11 (10 - 12)	16 (15 - 16)	29 (26 - 32)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.6.6

Copper — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	0.23	12 (11 - 12)	4.7 (4.3 - 5.1)	13 (12 - 14)	18 (17 - 19)	28 (25 - 30)
Males, 6–11	1	524	0	11 (8.8 - 13)	3.9 (2.5 - 5.3)	12 (9.6 - 14)	17 (15 - 19)	27 (25 - 28)
Males, 6–11	2	532	0	13 (12 - 14)	6.5 (5.5 - 7.5)	14 (13 - 15)	18 (16 - 19)	25 (21 - 29)
Males, 12–19	1	505	0.40	12 (10 - 14)	4.8 (3.4 - 6.2)	13 (12 - 14)	17 (16 - 19)	29 (26 - 31)
Males, 12–19	2	542	0.18	13 (12 - 15)	6.2 (5.3 - 7.2)	14 (13 - 16)	18 (17 - 20)	28 (24 - 33)
Males, 20–39	1	514	0.19	9.4 (8.1 - 11)	3.3^{E} (1.6 - 5.1)	9.9 (8.9 - 11)	16 (15 - 18)	26 (23 - 29)
Males, 20–39	2	551	0.18	11 (10 - 13)	4.6 (3.7 - 5.5)	12 (11 - 13)	19 (16 - 22)	29 (26 - 33)
Males, 40–59	1	578	0.52	9.6 (8.6 - 11)	3.6 (2.9 - 4.3)	11 (9.9 - 12)	15 (14 - 17)	26 (23 - 30)
Males, 40–59	2	616	0.49	11 (10 - 13)	3.7 (2.5 - 4.9)	12 (10 - 14)	18 (16 - 20)	27 (25 - 29)
Males, 60–79	1	541	0	11 (9.9 - 12)	4.8 (4.2 - 5.3)	11 (10 - 12)	16 (14 - 17)	27 (23 - 31)
Males, 60–79	2	505	0	11 (10 - 12)	4.3 (3.2 - 5.4)	12 (11 - 12)	16 (15 - 17)	29 (25 - 33)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	0.18	10 (9.7 - 11)	3.7 (3.3 - 4.1)	11 (11 - 12)	17 (16 - 17)	28 (26 - 29)
Females, 6–11	1	510	0.59	10 (9.4 - 11)	3.5 (2.7 - 4.3)	11 (10 - 12)	17 (16 - 18)	28 (24 - 32)
Females, 6–11	2	530	0	13 (12 - 14)	5.1 (4.5 - 5.7)	13 (12 - 14)	19 (17 - 21)	27 (26 - 29)
Females, 12–19	1	478	0.21	13 (11 - 15)	3.8^{E} (2.1 - 5.4)	14 (13 - 16)	22 (19 - 25)	34 (30 - 39)
Females, 12–19	2	499	0	13 (11 - 14)	5.0 (4.1 - 5.9)	13 (12 - 15)	19 (17 - 21)	33 (26 - 39)
Females, 20–39	1	655	0.61	7.9 (6.9 - 9.0)	3.0 (2.6 - 3.3)	8.6 (7.2 - 10)	13 (12 - 15)	24 (20 - 28)
Females, 20–39	2	770	0.39	10 (9.3 - 12)	3.6 (2.6 - 4.6)	12 (10 - 13)	18 (16 - 20)	27 (18 - 36)
Females, 40–59	1	645	0.31	6.9 (6.1 - 7.9)	1.8^{E} (0.63 - 3.0)	7.6 (6.3 - 8.9)	12 (11 - 13)	21 (18 - 25)
Females, 40–59	2	612	0.33	9.3 (8.4 - 10)	3.5 (2.5 - 4.4)	11 (9.5 - 12)	15 (14 - 16)	25 (20 - 30)
Females, 60–79	1	542	0	7.6 (6.8 - 8.5)	2.9 (2.6 - 3.3)	8.1 (6.7 - 9.5)	12 (11 - 13)	22 (20 - 25)
Females, 60–79	2	581	0.17	9.1 (8.3 - 9.9)	3.5 (3.0 - 4.0)	9.9 (8.8 - 11)	15 (13 - 17)	29 (24 - 34)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.6.7

Copper (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5479	0.29	11 (10 - 11)	7.4 (7.1 - 7.7)	10 (9.9 - 10)	13 (12 - 13)	20 (19 - 21)
Total, 6–79	2	5719	0.19	10 (9.9 - 10)	6.9 (6.7 - 7.1)	9.7 (9.5 - 10)	12 (12 - 12)	19 (18 - 20)
Males, Total 6–79	1	2653	0.23	10 (9.5 - 10)	6.9 (6.6 - 7.1)	9.6 (9.3 - 9.9)	11 (11 - 12)	18 (17 - 19)
Males, Total 6–79	2	2739	0.18	9.3 (9.0 - 9.5)	6.6 (6.3 - 6.8)	8.8 (8.5 - 9.1)	11 (11 - 11)	17 (15 - 18)
Females, Total 6–79	1	2826	0.35	12 (11 - 12)	8.2 (7.7 - 8.6)	11 (11 - 11)	14 (13 - 14)	22 (20 - 23)
Females, Total 6–79	2	2980	0.20	11 (11 - 11)	7.9 (7.6 - 8.2)	11 (10 - 11)	13 (12 - 13)	20 (19 - 21)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.6.8

Copper (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6291	0.21	10 (10 - 11)	7.0 (6.8 - 7.2)	9.9 (9.7 - 10)	12 (12 - 13)	21 (20 - 21)
3–5[b]	1							
3–5	2	572	0.35	21 (20 - 22)	16 (14 - 17)	21 (20 - 22)	25 (24 - 26)	32 (30 - 35)
6–11	1	1031	0.29	16 (15 - 17)	11 (10 - 12)	15 (15 - 16)	18 (18 - 19)	26 (23 - 29)
6–11	2	1058	0	14 (14 - 15)	11 (10 - 11)	14 (14 - 15)	17 (17 - 18)	22 (21 - 23)
12–19	1	982	0.31	11 (10 - 11)	7.4 (7.0 - 7.8)	9.9 (9.7 - 10)	12 (11 - 13)	20 (17 - 22)
12–19	2	1039	0.10	9.7 (9.3 - 10)	6.9 (6.7 - 7.1)	9.2 (8.8 - 9.6)	11 (11 - 12)	17 (15 - 19)
20–39	1	1165	0.43	9.6 (9.1 - 10)	6.7 (6.3 - 7.0)	9.5 (9.1 - 9.9)	11 (10 - 11)	15 (14 - 17)
20–39	2	1319	0.30	9.0 (8.7 - 9.2)	6.5 (6.1 - 6.9)	8.7 (8.3 - 9.1)	11 (10 - 11)	15 (14 - 16)
40–59	1	1218	0.41	10 (9.9 - 11)	7.4 (7.1 - 7.8)	10 (9.8 - 10)	12 (11 - 12)	17 (16 - 18)
40–59	2	1223	0.41	9.9 (9.5 - 10)	7.1 (6.8 - 7.4)	9.6 (9.3 - 9.9)	11 (11 - 12)	16 (14 - 18)
60–79	1	1083	0	13 (12 - 13)	8.6 (8.1 - 9.2)	12 (11 - 12)	14 (14 - 15)	22 (19 - 25)
60–79	2	1080	0.09	12 (11 - 12)	8.2 (7.9 - 8.5)	11 (11 - 12)	14 (13 - 15)	21 (20 - 23)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.6.9

Copper (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	0.23	9.5 (9.2 - 9.8)	6.6 (6.4 - 6.9)	9.0 (8.7 - 9.2)	11 (11 - 12)	19 (18 - 20)
Males, 6–11	1	522	0	16 (15 - 17)	11 (11 - 12)	15 (15 - 16)	18 (17 - 19)	27 (22 - 31)
Males, 6–11	2	530	0	14 (14 - 15)	11 (10 - 11)	14 (13 - 15)	17 (16 - 18)	21 (18 - 23)
Males, 12–19	1	504	0.40	10 (9.3 - 11)	7.2 (6.8 - 7.6)	9.6 (9.2 - 10)	12 (11 - 13)	17 (15 - 20)
Males, 12–19	2	541	0.18	9.0 (8.5 - 9.6)	6.6 (6.2 - 7.0)	8.6 (8.2 - 9.1)	11 (9.4 - 12)	15 (13 - 16)
Males, 20–39	1	512	0.20	8.7 (8.2 - 9.2)	6.4 (6.1 - 6.7)	8.5 (8.0 - 9.0)	9.9 (9.6 - 10)	13 (12 - 14)
Males, 20–39	2	550	0.18	7.9 (7.6 - 8.3)	6.0 (5.6 - 6.3)	7.7 (7.3 - 8.1)	9.3 (8.8 - 9.8)	13 (11 - 15)
Males, 40–59	1	574	0.52	9.5 (8.8 - 10)	7.0 (6.7 - 7.4)	9.4 (9.0 - 9.9)	11 (10 - 11)	16 (13 - 19)
Males, 40–59	2	615	0.49	9.1 (8.8 - 9.5)	6.8 (6.5 - 7.0)	8.7 (8.3 - 9.1)	10 (9.9 - 11)	14 (11 - 16)
Males, 60–79	1	541	0	11 (11 - 12)	7.7 (7.2 - 8.3)	10 (9.8 - 11)	13 (12 - 14)	20 (17 - 24)
Males, 60–79	2	503	0	11 (10 - 11)	7.8 (7.5 - 8.1)	10 (9.7 - 11)	12 (12 - 12)	19 (16 - 21)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	0.18	11 (11 - 12)	7.9 (7.6 - 8.2)	11 (10 - 11)	13 (13 - 14)	22 (21 - 23)
Females, 6–11	1	509	0.59	16 (15 - 17)	11 (9.7 - 12)	16 (15 - 17)	19 (18 - 20)	25 (21 - 28)
Females, 6–11	2	528	0	15 (14 - 15)	11 (10 - 12)	15 (14 - 15)	17 (17 - 18)	22 (21 - 24)
Females, 12–19	1	478	0.21	11 (11 - 12)	7.7 (7.1 - 8.2)	10 (9.6 - 11)	12 (12 - 13)	25 (17 - 33)
Females, 12–19	2	498	0	10 (10 - 11)	7.4 (7.0 - 7.8)	9.7 (9.1 - 10)	12 (11 - 12)	20 (17 - 22)
Females, 20–39	1	653	0.61	11 (10 - 11)	7.7 (7.3 - 8.2)	10 (9.8 - 10)	12 (11 - 12)	18 (14 - 23)
Females, 20–39	2	769	0.39	10 (9.7 - 11)	7.3 (6.8 - 7.9)	9.6 (8.9 - 10)	11 (11 - 12)	17 (15 - 18)
Females, 40–59	1	644	0.31	12 (11 - 12)	8.2 (7.5 - 8.9)	11 (10 - 11)	13 (12 - 13)	20 (16 - 23)
Females, 40–59	2	608	0.33	11 (10 - 11)	8.0 (7.4 - 8.7)	10 (9.9 - 11)	12 (12 - 13)	19 (15 - 22)
Females, 60–79	1	542	0	14 (13 - 14)	9.9 (9.2 - 11)	13 (12 - 13)	16 (15 - 17)	24 (21 - 28)
Females, 60–79	2	577	0.17	13 (12 - 14)	9.1 (8.5 - 9.6)	12 (12 - 13)	15 (14 - 16)	23 (19 - 27)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

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8.7 FLUORIDE

Fluorine (CASRN 16984-48-8) is the 13th most abundant element, occurring naturally in the Earth's crust at an average concentration of about 0.09% (ATSDR, 2003). It is widely distributed and naturally occurring, but it is rarely found in nature because it reacts readily with most organic and inorganic substances. Fluorides are formed when fluorine reacts with metals. Four inorganic fluorides of environmental importance are calcium fluoride (fluorspar and fluorite), sodium fluoride, sulphur hexafluoride, and hydrogen fluoride (Cotton & Wilkinson, 1988; Mackay & Mackay, 1989).

Fluorides are found in rocks, coal, clay, and soil. Gases and particles produced from volcanic eruptions and minerals leached from bedrock release inorganic fluorides into the environment (ATSDR, 2003; CCME, 2002). In addition to these natural sources, inorganic fluorides are released through human activities such as phosphate fertilizer production, chemical production, and aluminum smelting (Environment Canada & Health Canada, 1993).

Hydrogen fluoride is one of the most commonly used fluoride compounds; it is a component in the production of refrigerants, herbicides, pharmaceuticals, aluminum, plastics, high-octane gasoline, electrical components, and fluorescent light bulbs (ATSDR, 2003). In water, hydrogen fluoride becomes hydrofluoric acid, which is used in the metal and glass manufacturing industries (ATSDR, 2003). Calcium fluoride is used in the production of steel, aluminum, glass, and enamel, and as the raw material for the production of hydrofluoric acid and hydrogen fluoride (CCME, 2002). Sodium fluoride is often added to drinking water and dental products to prevent dental cavities. Toothpastes are the most commonly used dental product that contain fluoride (Health Canada, 2010a). Other fluoride-containing dental products available to consumers include fluoride supplements, fluoride mouth rinses, and dental floss. Sodium fluoride is also used as a preservative in wood and glues and in the production of glass, enamel, steel, and aluminum (CCME, 2002). Sulphur hexafluoride is used extensively in electrical switch gear such as power circuit breakers, compressed gas transmission lines, and various components in electrical substations (CCME, 2002).

Fluoride compounds are ubiquitous in the environment; however, the major sources of exposure to the general population are water, food, beverages, and dental products (Health Canada, 2010a). Following ingestion of soluble fluoride salts and inhalation of gaseous hydrogen fluoride, fluoride is rapidly and efficiently absorbed (ATSDR, 2003). Once absorbed, fluoride is rapidly distributed throughout the body via the bloodstream (ATSDR, 2003). In infants, about 80% to 90% of the total absorbed fluoride is retained in bones and teeth with the level dropping to about 60% in adults (Fawell et al., 2006). The remaining fluoride in adults and infants is excreted through urine (ATSDR, 2003). The biological half-life of fluoride is on the order of several hours (ATSDR, 2003; NRC, 2006). Urine and blood analyses are the most common tests for fluoride exposure (ATSDR, 2003).

The primary adverse effects associated with chronic excess fluoride intake are dental and skeletal fluorosis (IOM, 1997). Exposure to excessive levels of fluoride over a very long period of time can lead to skeletal fluorosis characterized by dense bones, joint pain, and limited range of joint movement (ATSDR, 2003). Dense bones are often more brittle or fragile than normal bones and there is an increased risk of bone fractures in older adults. Dental fluorosis is a dose-response effect caused by fluoride ingestion during tooth formation that becomes apparent upon eruption of the teeth. The effects of dental fluorosis can range from mild discolouration of the tooth surface to severe staining, enamel loss, and pitting (NRC, 2006).

Health Canada found that the weight of evidence from existing scientific data does not support an association between fluoride and increased risks of cancer, and has classified fluoride in Group VI, unclassifiable with respect to carcinogenicity in humans (Health Canada, 2010a). Similarly, the International Agency for Research on Cancer has classified fluorides (inorganic, used in drinking water) as Group 3, not classifiable as to its carcinogenicity to humans (IARC, 1987).

Health Canada and Environment Canada have reviewed and assessed inorganic fluorides under the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999). The screening assessment concluded that levels of inorganic fluorides normally found in the Canadian environment are not considered harmful to human health but are a concern for the environment (Environment Canada & Health Canada, 1993). Inorganic fluorides are listed on Schedule 1, List of Toxic Substances, under CEPA 1999. The Act allows the federal government to control the importation, manufacture, distribution, and use of inorganic fluorides in Canada (Canada, 1999; Canada, 2000).

Health Canada does not consider fluoride to be an essential element and recommends that fluoride requirements be based only on the beneficial effect on dental caries (Health Canada, 2010a). Young children tend to swallow toothpaste during brushing, so guidelines have been established that strive to balance the health risks with the health benefits of fluoride use. In general, toothpaste use is not recommended for children under the age of 3 and for children 3 to 6 years old, Health Canada recommends supervision during brushing and use of only a small amount of fluoridated toothpaste (Health Canada, 2010b).

Health Canada recently completed a review of the health risks associated with fluoride in drinking water in which moderate dental fluorosis was chosen as the endpoint of concern for fluoride (Health Canada, 2010a). Although moderate dental fluorosis is not a health concern and is not considered to be a toxicological endpoint, Health Canada considers it to be an adverse effect based on its potential aesthetic concern. The current Canadian drinking water quality guideline developed by Health Canada sets out the maximum acceptable concentration of fluoride (Health Canada, 2010a). This guideline is considered to be protective against all potential adverse health effects including those related to cancer, immunotoxicity, reproductive/developmental toxicity, genotoxicity, and/or neurotoxicity (Health Canada, 2010a). For communities wishing to fluoridate their water supply, Health Canada has determined an optimal concentration of fluoride in drinking water to promote dental health while protecting against adverse effects (Health Canada, 2010b). Tolerable upper intake levels for fluoride, which account for its potential toxicity, have been developed by the Institute of Medicine and adopted by Health Canada (Health Canada, 2010c; IOM, 1997).

The concentration of fluoride in some foods and prepackaged water and ice is regulated by Health Canada under the *Food and Drug Regulations* (Canada, 2012). Food tolerances for fluoride currently exist for edible bone meal and fish protein as well as prepackaged ice or water, including those represented as mineral or spring water (Canada, 2012).

The first cycle (2007–2009) of the Canadian Health Measures Survey (CHMS) included a National Oral Health Component supported by Health Canada (Health Canada, 2010d). In addition to many other dental considerations, dental fluorosis was measured in children ranging from 6 to 12 years old. The results from cycle 1 of the CHMS found that 60% of children had teeth considered normal, 24% had enamel with white flecks or spots where the cause was questionable, 12% had one or more teeth with fluorosis classified as very mild, and 4% had fluorosis classified as mild. The prevalence of moderate or severe fluorosis was too low to allow reporting (less than 0.3%).

Fluoride was measured in the urine of all CHMS cycle 2 (2009–2011) participants aged 3 to 79 years and is presented as both µg/L and µg/g creatinine (Tables 8.7.1, 8.7.2, 8.7.3, and 8.7.4). Finding a measurable amount of fluoride in urine is an indicator of exposure to fluoride and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary fluoride in the Canadian population.

Table 8.7.1

Fluoride — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2530	0	500 (460 - 550)	190 (180 - 210)	480 (430 - 540)	840 (750 - 930)	1500 (1300 - 1800)
3–5	2	510	0	470 (420 - 520)	190 (140 - 230)	510 (440 - 590)	720 (620 - 820)	1300 (920 - 1700)
6–11	2	514	0	500 (440 - 570)	200 (170 - 240)	490 (410 - 560)	820 (720 - 910)	1500 (1100 - 1800)
12–19	2	507	0	410 (370 - 460)	170 (150 - 200)	440 (360 - 520)	660 (570 - 750)	1200 (990 - 1400)
20–39	2	354	0	530 (470 - 590)	220 (190 - 260)	500 (380 - 620)	900 (750 - 1100)	1500 (1200 - 1800)
40–59	2	357	0	510 (430 - 610)	190 (130 - 250)	510 (410 - 620)	880 (740 - 1000)	1800 (1400 - 2300)
60–79	2	288	0	490 (440 - 560)	190[E] (120 - 260)	470 (410 - 540)	830 (760 - 910)	1600 (1200 - 2000)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.7.2

Fluoride — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1267	0	530 (470 - 600)	220 (200 - 250)	510 (420 - 600)	870 (740 - 1000)	1600 (1400 - 1900)
Males, 6–11	2	262	0	530 (440 - 620)	210 (170 - 260)	500 (350 - 640)	880 (730 - 1000)	1500 (1100 - 1800)
Males, 12–19	2	255	0	430 (370 - 480)	190 (150 - 220)	420 (310 - 520)	650 (560 - 740)	1400 (1000 - 1700)
Males, 20–39	2	166	0	590 (460 - 750)	260 (220 - 300)	600[E] (370 - 840)	980 (720 - 1200)	x
Males, 40–59	2	192	0	530 (410 - 670)	210 (130 - 280)	510 (350 - 680)	880 (620 - 1100)	x
Males, 60–79	2	141	0	540 (470 - 600)	230 (170 - 280)	510 (390 - 630)	860 (740 - 980)	x
Females, Total 3–79	2	1263	0	470 (430 - 520)	180 (150 - 200)	470 (410 - 530)	800 (700 - 900)	1300 (1000 - 1600)
Females, 6–11	2	252	0	480 (410 - 560)	200 (140 - 250)	470 (400 - 550)	730 (540 - 910)	1200[E] (660 - 1800)
Females, 12–19	2	252	0	400 (340 - 460)	160 (120 - 200)	450 (370 - 530)	700 (530 - 860)	1100 (1000 - 1300)
Females, 20–39	2	188	0	470 (410 - 540)	190 (160 - 230)	430 (310 - 560)	750 (620 - 890)	x
Females, 40–59	2	165	0	500 (400 - 620)	180[E] (110 - 240)	510 (350 - 660)	850 (680 - 1000)	x
Females, 60–79	2	147	0	460 (360 - 580)	F	460 (360 - 560)	800 (610 - 1000)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 8.7.3

Fluoride (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2520	0	500 (450 - 550)	210 (190 - 230)	480 (420 - 550)	800 (710 - 900)	1700 (1300 - 2000)
3–5	2	509	0	810 (730 - 900)	400 (340 - 470)	790 (720 - 860)	1100 (890 - 1200)	2800^{E} (1700 - 3900)
6–11	2	512	0	580 (530 - 630)	310 (290 - 330)	570 (510 - 640)	830 (700 - 960)	1600 (1100 - 2100)
12–19	2	505	0	320 (280 - 350)	150 (130 - 170)	330 (280 - 370)	460 (390 - 530)	760 (540 - 980)
20–39	2	352	0	460 (390 - 550)	210 (170 - 250)	430 (340 - 510)	670 (490 - 850)	F
40–59	2	355	0	530 (460 - 600)	220 (180 - 260)	550 (430 - 670)	850 (730 - 980)	1600 (1200 - 2100)
60–79	2	287	0	580 (500 - 680)	220 (170 - 270)	560 (440 - 680)	970 (770 - 1200)	2100 (1500 - 2600)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.7.4

Fluoride (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1263	0	460 (400 - 530)	200 (170 - 240)	430 (370 - 500)	710 (610 - 810)	1300 (950 - 1700)
Males, 6–11	2	261	0	600 (540 - 670)	320 (290 - 360)	590 (530 - 650)	840 (680 - 1000)	1300^{E} (640 - 2000)
Males, 12–19	2	254	0	300 (270 - 340)	150 (120 - 180)	280 (240 - 330)	430 (350 - 520)	700 (550 - 850)
Males, 20–39	2	165	0	450 (360 - 560)	200 (140 - 260)	410 (340 - 490)	600 (430 - 780)	x
Males, 40–59	2	192	0	460 (400 - 540)	210 (140 - 280)	440 (340 - 550)	700 (590 - 810)	x
Males, 60–79	2	141	0	510 (440 - 590)	210^{E} (130 - 290)	490 (400 - 580)	870 (710 - 1000)	x
Females, Total 3–79	2	1257	0	540 (490 - 600)	210 (180 - 240)	530 (460 - 600)	900 (780 - 1000)	2000 (1500 - 2400)
Females, 6–11	2	251	0	560 (490 - 640)	290 (250 - 320)	510 (430 - 590)	830 (650 - 1000)	1800 (1200 - 2300)
Females, 12–19	2	251	0	330 (290 - 380)	150 (120 - 170)	350 (300 - 400)	480 (410 - 550)	760^{E} (350 - 1200)
Females, 20–39	2	187	0	480 (390 - 590)	220 (160 - 280)	490 (370 - 610)	750 (490 - 1000)	x
Females, 40–59	2	163	0	600 (490 - 730)	230^{E} (110 - 350)	680 (520 - 840)	990 (830 - 1200)	x
Females, 60–79	2	146	0	660 (510 - 840)	230 (<LOD - 300)	630 (410 - 850)	1300 (820 - 1700)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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8.8 LEAD

Lead (CASRN 7439-92-1) is a naturally occurring element present in the Earth's crust at an average concentration of approximately 0.0014% (Emsley, 2001). It is a base metal and can exist in various oxidation states and in both inorganic and organic forms (ATSDR, 2007). Inorganic forms include substances such as elemental lead, lead sulphate, lead carbonates and oxycarbonates, lead oxides, and lead halides. Organic lead compounds include tetra-alkyl, trialkyl, and dialkyl lead compounds.

Lead is found in bedrock, soils, sediments, surface water, groundwater, and sea water (Health Canada, 2012a). It enters the environment from a variety of natural and anthropogenic sources. Natural processes include soil weathering, erosion, and volcanic activity (ATSDR, 2007; IARC, 2006). Lead released from industrial emissions can be a major source of environmental contamination, especially near point sources such as smelters or refineries (ATSDR, 2007). Historical use of leaded motor fuels has contributed to the ubiquitous distribution of lead throughout the globe (WHO, 2000).

In North America, tetraethyl and tetramethyl lead were used as anti-knock additives in motor vehicle fuels up until the 1990s. Presently in Canada, lead use in gasoline is limited to fuels for piston engine aircrafts and racing fuels for competition vehicles (Health Canada, 2013a). Lead is currently used in the refining and manufacturing of products such as lead acid automotive batteries, lead shot and fishing weights, sheet lead, lead solder, some brass and bronze products, and some ceramic glazes (ATSDR, 2007; WHO, 2000). Other uses of lead include dyes in paints and pigments. It is also used in scientific equipment, as a stabilizer in plastics, in military equipment and ammunition, and in medical equipment as radiation shields (ATSDR, 2007; WHO, 2000). Lead is also used in the manufacturing of cable sheathing, circuit boards, chemical baths and storage vessel linings, chemical transmission pipes, electrical components, and polyvinyl chloride (Health Canada, 2013a).

Everyone is exposed to trace amounts of lead through food, drinking water, soil, household dust, air, and some consumer products. Over the past 30 years, lead exposure has declined by over 70% in Canada (Bushnik et al., 2010; Health Canada, 2011a; Health Canada, 2013a). The substantial decrease in lead is attributed mainly to the phase-out of leaded gasoline, reduction of lead content in lead-based paints, and the elimination of lead solder in food cans (Health Canada, 2011a). Today, the main route of exposure for the general adult population is from ingestion of food and drinking water (ATSDR, 2007; Health Canada, 2013a). For infants and children, the primary route of exposure is food, drinking water, and the ingestion of non-food items containing lead such as house dust, lead-based paint, soil, and products (Health Canada, 2013a). Lead can enter the water supply from old lead service connections (pipes) or lead solder in the plumbing in homes. Other potential sources of exposure include products that may contain lead, such as costume jewellery, art supplies, leaded crystal, and glazes on ceramics and pottery; working on a hobby that involves the use of lead or lead solder, such as making stained glass, ceramic glazing, lead shot or lead fishing weights, and furniture refinishing; living in or frequently visiting older buildings that contain deteriorating lead paint or that are undergoing renovation activities; and behaviours such as smoking (Health Canada 2011a).

Approximately 3% to 10% of ingested lead is absorbed into blood in adults; the amount absorbed can increase to up to 40% to 50% in children (Health Canada, 2013a). Nutritional iron and calcium deficiencies in children appear to increase lead absorption (Health Canada, 2013a). Once absorbed by the human body, lead circulates in the bloodstream and either accumulates in tissues, particularly bone, or is excreted from the body. Some lead may also be absorbed into soft tissues such as the liver, kidneys, pancreas, and lungs. Bones account for approximately 70% of the total body burden of lead in children and more than 90% of the total body burden in human adults (EPA, 2006). Lead stored in bone can be remobilized and released back into circulating blood. Under certain conditions such as pregnancy, lactation, menopause, andropause, extended bed rest, hyperparathyroidism, and osteoporosis, lead can be mobilized at an increased rate (Health Canada, 2013a).

During pregnancy, lead stored in maternal bone becomes a source of fetal exposure (Rothenberg et al., 2000). Lead can also be present in breast milk and is transferred from lactating mothers to infants (ATSDR, 2007; EPA, 2006). The half-life for lead in blood is approximately 30 days, whereas the half-life for lead accumulated in the body, such as in bone, is around 10 to 30 years (ATSDR, 2007; Health Canada, 2007; Health Canada, 2013a). Excretion of absorbed lead, independent of the route of exposure, occurs primarily in urine and feces (ATSDR, 2007). Blood lead is the preferred indicator of human exposure to lead, although other matrices such as urine, bone, and teeth have also been used (ATSDR, 2007; CDC, 2009).

Lead is considered a cumulative general poison, with fetuses, infants, toddlers, and children being most susceptible to adverse health effects (WHO, 2011). Following acute exposure, a variety of metabolic processes may be affected. Very high exposure may result in vomiting, diarrhea, convulsions, coma, and death. Severe cases of lead poisoning are rare in Canada (Health Canada, 2007). Symptoms of chronic exposure to relatively low levels of lead are often not apparent (ATSDR, 2007). Chronic low-level exposure may affect both the central and peripheral nervous systems (Health Canada, 2013a). Chronic low-level exposure to lead has also been associated with effects on neurodevelopment, the cardiovascular system, kidneys, the reproductive system, and other health endpoints (ATSDR, 2007; Health Canada, 2013a). Cognitive and neurobehavioural effects have been recognized as major concerns for children exposed to lead. In infants and children, neurodevelopmental effects are most strongly associated with lead exposure, specifically the reduction of intelligence quotient (Lanphear et al., 2005) and attention-related behaviours (Health Canada, 2013a). Based on available data, no threshold has yet been identified for the effects of lead exposure on cognitive function and neurobehavioural development (CDC, 2012; EPA, 2006; Health Canada, 2013a). Developmental neurotoxicity has been associated with the lowest levels of lead exposure to date (Health Canada, 2013a). The International Agency for Research on Cancer classifies inorganic lead compounds as Group 2A, probably carcinogenic to humans (IARC, 2006).

Lead is listed on Schedule 1, List of Toxic Substances, under the *Canadian Environmental Protection Act, 1999* (CEPA 1999). The Act allows the federal government to control the importation, manufacture, distribution, and use of lead and lead compounds in Canada (Canada, 1999; Health Canada, 2007). CEPA 1999 restricts the use of lead in gasoline and controls its release from secondary lead smelters, steel manufacturing, and mining effluents (Environment Canada, 2010). The use of lead in toys, children's jewellery and other products intended for children, glazed ceramics and glass foodware, and other consumer products representing a potential risk of lead exposure is restricted under the *Canada Consumer Product Safety Act* and its associated regulations (Canada, 2010a; Canada, 2010b; Health Canada, 2012a). Lead and its compounds are included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011c).

On the basis of health considerations, Health Canada has developed a Canadian drinking water quality guideline that sets out the maximum acceptable concentration of lead (Health Canada, 1992); this guideline is planned for review by Health Canada in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water (Health Canada, 2013b). Health Canada has also published guidance on controlling corrosion in drinking water distribution systems to help control the leaching of metals, including lead, that results from corrosion (Health Canada, 2009a). The concentration of lead in some foods is regulated by Health Canada under the *Food and Drug Regulations*; the current food tolerances are in the process of being updated (Canada, 2012; Health Canada, 2011b). Lead is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009b). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply.

In 1994, the Federal-Provincial-Territorial Committee on Environmental and Occupational Health recommended a blood lead intervention level of 10 µg/dL as guidance for low-level exposure to lead (CEOH, 1994). Recent scientific assessments indicate that chronic health effects are occurring in children at blood lead levels below 10 µg/dL and that there is sufficient evidence that blood lead levels below 5 µg/dL are associated with adverse health effects (Health Canada, 2013a). *Update of evidence for low-level effects of lead and blood-lead intervention levels and strategies* (CEOH, 1994) is currently under review by the federal, provincial, and territorial jurisdictions through the Committee on Health and Environment (Health Canada, 2013b).

In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric means for lead in whole blood and urine were 2.15 µg/dL and 0.12 µg/dL, respectively (INSPQ, 2004). Higher lead levels have been found in some northern communities; a geometric mean blood level of 3.9 µg/dL was measured from 917 adults aged 18 to 74 years in Nunavik, Quebec, in 2004 (Dewailly et al., 2007). More recently, a study conducted in Hamilton on 643 children aged 0 to 6 years reported a geometric mean blood lead level of 2.21 µg/dL (Richardson et al., 2011). A number of other studies that measured blood lead levels have been conducted in various locations in Canada over the years. In a recent report by Health Canada, blood lead levels were reported for various locations, age groups, and years. The reported geometric means ranged from 0.7 to 5.6 µg/dL for various age groups within the Canadian population (Health Canada, 2013a).

Lead was measured in the whole blood and urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented in blood as µg/dL (Tables 8.8.1, 8.8.2, and 8.8.3) and in urine as both µg/L (Tables 8.8.4, 8.8.5, and 8.8.6) and µg/g creatinine (Tables 8.8.7, 8.8.8, and 8.8.9). Finding a measurable amount of lead in blood and urine does not necessarily mean that an adverse health effect will occur.

Table 8.8.1

Lead — Geometric means and selected percentiles of whole blood concentrations (µg/dL) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5319	0.02	1.3 (1.2 - 1.4)	0.60 (0.56 - 0.64)	1.2 (1.2 - 1.3)	2.0 (1.8 - 2.2)	3.7 (3.3 - 4.2)
Total, 6–79	2	5575	0	1.2 (1.1 - 1.3)	0.54 (0.50 - 0.59)	1.2 (1.1 - 1.2)	1.8 (1.6 - 1.9)	3.2 (3.0 - 3.5)
Males, Total 6–79	1	2576	0	1.5 (1.4 - 1.6)	0.71 (0.65 - 0.76)	1.4 (1.3 - 1.5)	2.2 (1.9 - 2.4)	4.2 (3.6 - 4.7)
Males, Total 6–79	2	2687	0	1.3 (1.3 - 1.4)	0.62 (0.55 - 0.68)	1.3 (1.2 - 1.4)	1.9 (1.8 - 2.1)	3.5 (3.1 - 3.8)
Females, Total 6–79	1	2743	0.04	1.2 (1.1 - 1.3)	0.54 (0.50 - 0.59)	1.1 (0.98 - 1.2)	1.7 (1.5 - 1.9)	3.5 (3.0 - 3.9)
Females, Total 6–79	2	2888	0	1.1 (1.0 - 1.1)	0.50 (0.45 - 0.54)	1.1 (0.98 - 1.1)	1.5 (1.4 - 1.7)	2.8 (2.6 - 3.0)

[a] For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.8.2

Lead — Geometric means and selected percentiles of whole blood concentrations (µg/dL) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6070	0	1.2 (1.1 - 1.2)	0.54 (0.50 - 0.59)	1.2 (1.1 - 1.2)	1.7 (1.6 - 1.8)	3.2 (2.9 - 3.4)
3–5[b]	1							
3–5	2	495	0	0.93 (0.86 - 1.0)	0.51 (0.44 - 0.58)	0.93 (0.86 - 1.0)	1.2 (1.1 - 1.3)	2.1 (1.8 - 2.3)
6–11	1	910	0	0.89 (0.81 - 0.99)	0.53 (0.49 - 0.56)	0.87 (0.77 - 0.97)	1.1 (1.0 - 1.3)	1.9 (1.6 - 2.2)
6–11	2	961	0	0.79 (0.74 - 0.84)	0.43 (0.37 - 0.49)	0.74 (0.68 - 0.80)	1.0 (0.93 - 1.2)	1.8 (1.5 - 2.0)
12–19	1	945	0	0.79 (0.74 - 0.85)	0.47 (0.44 - 0.50)	0.76 (0.69 - 0.83)	1.0 (0.94 - 1.1)	1.6 (1.4 - 1.8)
12–19	2	997	0	0.71 (0.68 - 0.75)	0.39 (0.35 - 0.43)	0.68 (0.64 - 0.72)	0.94 (0.88 - 1.0)	1.6 (1.3 - 1.9)
20–39	1	1165	0.09	1.1 (1.0 - 1.2)	0.57 (0.52 - 0.62)	1.0 (0.94 - 1.1)	1.5 (1.3 - 1.7)	3.1 (2.7 - 3.4)
20–39	2	1313	0	0.98 (0.88 - 1.1)	0.49 (0.42 - 0.57)	0.95 (0.87 - 1.0)	1.3 (1.2 - 1.5)	2.2 (1.6 - 2.8)
40–59	1	1220	0	1.6 (1.5 - 1.8)	0.82 (0.69 - 0.94)	1.5 (1.4 - 1.6)	2.2 (1.9 - 2.5)	3.8 (3.1 - 4.5)
40–59	2	1222	0	1.4 (1.3 - 1.5)	0.70 (0.61 - 0.78)	1.4 (1.3 - 1.5)	2.0 (1.8 - 2.2)	3.2 (2.9 - 3.5)
60–79	1	1079	0	2.1 (1.9 - 2.3)	1.0 (0.92 - 1.1)	2.0 (1.8 - 2.2)	3.0 (2.6 - 3.3)	5.2 (4.2 - 6.2)
60–79	2	1082	0	1.9 (1.8 - 1.9)	1.0 (0.95 - 1.1)	1.8 (1.7 - 1.9)	2.5 (2.4 - 2.6)	4.2 (3.9 - 4.5)

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[b] Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.8.3

Lead — Geometric means and selected percentiles of whole blood concentrations (μg/dL) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2940	0	1.3 (1.3 - 1.4)	0.62 (0.56 - 0.68)	1.3 (1.2 - 1.4)	1.9 (1.7 - 2.1)	3.4 (3.1 - 3.7)
Males, 6–11	1	459	0	0.92 (0.85 - 0.99)	0.54 (0.50 - 0.58)	0.89 (0.79 - 0.99)	1.2 (1.1 - 1.3)	1.9 (1.8 - 2.1)
Males, 6–11	2	488	0	0.79 (0.73 - 0.86)	0.43 (0.35 - 0.52)	0.75 (0.67 - 0.82)	1.1 (0.96 - 1.2)	1.7 (1.4 - 1.9)
Males, 12–19	1	489	0	0.88 (0.81 - 0.95)	0.51 (0.46 - 0.55)	0.87 (0.79 - 0.95)	1.1 (0.99 - 1.2)	1.7 (1.3 - 2.2)
Males, 12–19	2	523	0	0.84 (0.80 - 0.87)	0.48 (0.45 - 0.52)	0.79 (0.73 - 0.84)	1.1 (1.0 - 1.1)	1.8 (1.6 - 2.1)
Males, 20–39	1	514	0	1.4 (1.3 - 1.5)	0.75 (0.65 - 0.85)	1.3 (1.1 - 1.4)	2.0 (1.6 - 2.3)	3.6 (2.9 - 4.3)
Males, 20–39	2	552	0	1.1 (1.0 - 1.3)	0.60 (0.44 - 0.75)	1.1 (0.95 - 1.2)	1.5 (1.4 - 1.7)	2.4[E] (1.4 - 3.3)
Males, 40–59	1	577	0	1.7 (1.6 - 1.9)	0.98 (0.90 - 1.1)	1.6 (1.4 - 1.7)	2.3 (1.9 - 2.7)	4.0 (3.0 - 4.9)
Males, 40–59	2	617	0	1.6 (1.5 - 1.7)	0.84 (0.77 - 0.92)	1.6 (1.4 - 1.7)	2.1 (1.9 - 2.4)	3.5 (2.3 - 4.7)
Males, 60–79	1	537	0	2.3 (2.1 - 2.6)	1.1 (1.0 - 1.3)	2.2 (2.0 - 2.4)	3.3 (2.9 - 3.7)	6.2 (4.9 - 7.4)
Males, 60–79	2	507	0	2.0 (1.9 - 2.2)	1.1 (1.0 - 1.2)	2.0 (1.8 - 2.2)	2.7 (2.6 - 2.9)	4.2 (3.9 - 4.5)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3130	0	1.1 (1.0 - 1.1)	0.50 (0.45 - 0.54)	1.0 (0.98 - 1.1)	1.5 (1.4 - 1.6)	2.8 (2.6 - 3.0)
Females, 6–11	1	451	0	0.87 (0.77 - 0.99)	0.51 (0.45 - 0.57)	0.85 (0.73 - 0.96)	1.1 (0.88 - 1.3)	1.9 (1.2 - 2.5)
Females, 6–11	2	473	0	0.78 (0.72 - 0.85)	0.43 (0.37 - 0.49)	0.71 (0.63 - 0.78)	0.99 (0.84 - 1.1)	1.8 (1.5 - 2.1)
Females, 12–19	1	456	0	0.71 (0.66 - 0.77)	0.43 (0.37 - 0.48)	0.68 (0.61 - 0.75)	0.91 (0.80 - 1.0)	1.4 (1.2 - 1.6)
Females, 12–19	2	474	0	0.60 (0.56 - 0.65)	0.36 (0.32 - 0.39)	0.58 (0.52 - 0.63)	0.77 (0.70 - 0.84)	1.2 (1.1 - 1.4)
Females, 20–39	1	651	0.15	0.89 (0.81 - 0.97)	0.52 (0.46 - 0.57)	0.86 (0.77 - 0.96)	1.1 (1.0 - 1.3)	2.0 (1.7 - 2.3)
Females, 20–39	2	761	0	0.85 (0.74 - 0.98)	0.46 (0.36 - 0.56)	0.83 (0.73 - 0.93)	1.2 (1.0 - 1.4)	1.9 (1.4 - 2.4)
Females, 40–59	1	643	0	1.5 (1.3 - 1.6)	0.71 (0.59 - 0.82)	1.4 (1.2 - 1.6)	2.1 (1.7 - 2.4)	3.8 (3.1 - 4.5)
Females, 40–59	2	605	0	1.3 (1.2 - 1.4)	0.60 (0.52 - 0.68)	1.3 (1.2 - 1.4)	1.7 (1.5 - 2.0)	2.8 (2.5 - 3.0)
Females, 60–79	1	542	0	1.9 (1.7 - 2.1)	0.94 (0.82 - 1.0)	1.9 (1.6 - 2.1)	2.7 (2.3 - 3.0)	4.5 (3.8 - 5.2)
Females, 60–79	2	575	0	1.7 (1.6 - 1.8)	0.92 (0.79 - 1.1)	1.6 (1.5 - 1.8)	2.3 (2.1 - 2.5)	4.2 (3.5 - 4.8)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.8.4

Lead — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5492	7.54	0.48 (0.43 - 0.53)	<LOD[E] (<LOD - 0.16)	0.52 (0.47 - 0.58)	0.91 (0.83 - 1.0)	2.1 (1.8 - 2.4)
Total, 6–79	2	5738	16.23	0.52 (0.49 - 0.55)	<LOD	0.56 (0.52 - 0.60)	0.94 (0.87 - 1.0)	1.9 (1.7 - 2.0)
Males, Total 6–79	1	2662	5.86	0.54 (0.48 - 0.60)	0.14[E] (<LOD - 0.22)	0.59 (0.55 - 0.64)	1.0 (0.93 - 1.1)	2.3 (1.8 - 2.7)
Males, Total 6–79	2	2746	13.44	0.57 (0.54 - 0.61)	<LOD	0.63 (0.58 - 0.68)	1.0 (0.91 - 1.1)	2.1 (1.9 - 2.2)
Females, Total 6–79	1	2830	9.12	0.42 (0.37 - 0.48)	<LOD[E] (<LOD - 0.13)	0.45 (0.39 - 0.51)	0.79 (0.69 - 0.90)	1.8 (1.5 - 2.1)
Females, Total 6–79	2	2992	18.78	0.47 (0.44 - 0.50)	<LOD	0.50 (0.46 - 0.54)	0.86 (0.79 - 0.92)	1.8 (1.6 - 1.9)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.8.5

Lead — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6311	16.43	0.52 (0.49 - 0.54)	<LOD	0.56 (0.52 - 0.60)	0.93 (0.86 - 1.0)	1.9 (1.7 - 2.0)
3–5[b]	1							
3–5	2	573	18.50	0.48 (0.42 - 0.54)	<LOD	0.53 (0.47 - 0.58)	0.78 (0.68 - 0.88)	1.6 (1.2 - 2.1)
6–11	1	1034	9.28	0.36 (0.32 - 0.39)	<LOD	0.41 (0.37 - 0.45)	0.64 (0.57 - 0.72)	1.3 (1.1 - 1.4)
6–11	2	1062	18.46	0.41 (0.37 - 0.45)	<LOD	0.46 (0.40 - 0.52)	0.70 (0.63 - 0.76)	1.3 (1.1 - 1.6)
12–19	1	983	10.17	0.39 (0.34 - 0.44)	<LOD	0.43 (0.40 - 0.46)	0.73 (0.64 - 0.83)	1.5 (1.2 - 1.8)
12–19	2	1041	19.02	0.41 (0.38 - 0.45)	<LOD	0.46 (0.42 - 0.50)	0.70 (0.66 - 0.75)	1.3 (1.0 - 1.5)
20–39	1	1169	9.50	0.40 (0.35 - 0.47)	F	0.45 (0.39 - 0.51)	0.75 (0.63 - 0.87)	1.8 (1.6 - 2.1)
20–39	2	1321	19.68	0.45 (0.41 - 0.49)	<LOD	0.46 (0.43 - 0.50)	0.79 (0.69 - 0.89)	1.7 (1.2 - 2.1)
40–59	1	1223	5.97	0.54 (0.47 - 0.63)	0.16[E] (<LOD - 0.23)	0.61 (0.55 - 0.66)	0.99 (0.91 - 1.1)	2.3 (1.7 - 2.8)
40–59	2	1228	13.60	0.59 (0.54 - 0.66)	<LOD	0.66 (0.60 - 0.73)	1.0 (0.92 - 1.2)	2.0 (1.7 - 2.2)
60–79	1	1083	3.14	0.66 (0.60 - 0.73)	0.20 (0.15 - 0.24)	0.67 (0.62 - 0.73)	1.2 (1.1 - 1.4)	2.7 (2.1 - 3.3)
60–79	2	1086	10.13	0.65 (0.60 - 0.70)	<LOD	0.73 (0.65 - 0.81)	1.2 (1.1 - 1.3)	2.3 (2.0 - 2.7)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.8.6

Lead — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	13.57	0.57 (0.53 - 0.61)	<LOD	0.62 (0.58 - 0.67)	1.0 (0.91 - 1.1)	2.0 (1.9 - 2.2)
Males, 6–11	1	524	6.87	0.37 (0.31 - 0.45)	F	0.43 (0.32 - 0.53)	0.68 (0.57 - 0.79)	1.3 (1.0 - 1.6)
Males, 6–11	2	532	17.48	0.40 (0.35 - 0.45)	<LOD	0.42 (0.36 - 0.49)	0.69 (0.62 - 0.75)	1.2 (0.99 - 1.4)
Males, 12–19	1	505	9.11	0.38 (0.33 - 0.44)	<LOD	0.41 (0.37 - 0.45)	0.69 (0.59 - 0.78)	1.3 (0.89 - 1.8)
Males, 12–19	2	542	16.97	0.44 (0.39 - 0.49)	<LOD	0.49 (0.42 - 0.55)	0.71 (0.64 - 0.79)	1.3 (0.89 - 1.6)
Males, 20–39	1	514	7.00	0.46 (0.37 - 0.57)	F	0.53 (0.42 - 0.64)	0.95 (0.78 - 1.1)	2.0 (1.5 - 2.4)
Males, 20–39	2	551	14.88	0.50 (0.45 - 0.55)	<LOD	0.53 (0.48 - 0.59)	0.85 (0.69 - 1.0)	1.6[E] (0.98 - 2.1)
Males, 40–59	1	578	4.67	0.62 (0.54 - 0.72)	0.18 (0.12 - 0.23)	0.66 (0.60 - 0.72)	1.1 (0.94 - 1.2)	2.6 (1.8 - 3.5)
Males, 40–59	2	616	9.74	0.68 (0.61 - 0.77)	0.22 (<LOD - 0.30)	0.78 (0.66 - 0.90)	1.2 (0.98 - 1.4)	2.1 (1.8 - 2.5)
Males, 60–79	1	541	2.03	0.84 (0.74 - 0.95)	0.30 (0.23 - 0.38)	0.83 (0.67 - 1.0)	1.5 (1.3 - 1.7)	3.0 (2.6 - 3.5)
Males, 60–79	2	505	[illegible].32	0.73 (0.67 - 0.80)	0.23 (<LOD - 0.31)	0.79 (0.70 - 0.89)	1.3 (1.2 - 1.5)	2.3 (2.0 - 2.6)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	19.08	0.47 (0.44 - 0.50)	<LOD	0.50 (0.46 - 0.54)	0.85 (0.79 - 0.92)	1.8 (1.6 - 1.9)
Females, 6–11	1	510	11.76	0.34 (0.31 - 0.38)	<LOD	0.40 (0.37 - 0.43)	0.61 (0.55 - 0.68)	1.2 (1.0 - 1.4)
Females, 6–11	2	530	19.43	0.43 (0.38 - 0.48)	<LOD	0.48 (0.39 - 0.56)	0.75 (0.68 - 0.83)	1.5 (1.1 - 2.0)
Females, 12–19	1	478	11.30	0.40 (0.35 - 0.46)	F	0.44 (0.40 - 0.47)	0.79 (0.67 - 0.91)	1.6[E] (0.84 - 2.3)
Females, 12–19	2	499	21.24	0.39 (0.35 - 0.44)	<LOD	0.44 (0.38 - 0.50)	0.69 (0.62 - 0.76)	1.3 (1.0 - 1.6)
Females, 20–39	1	655	11.45	0.35 (0.30 - 0.40)	F	0.39 (0.34 - 0.45)	0.65 (0.55 - 0.75)	1.3 (1.1 - 1.5)
Females, 20–39	2	770	23.12	0.40 (0.35 - 0.45)	<LOD	0.40 (0.35 - 0.45)	0.70 (0.57 - 0.84)	1.7 (1.1 - 2.2)
Females, 40–59	1	645	7.13	0.47 (0.39 - 0.57)	0.15[E] (<LOD - 0.24)	0.53 (0.41 - 0.65)	0.94 (0.85 - 1.0)	2.0 (1.5 - 2.5)
Females, 40–59	2	612	17.48	0.52 (0.45 - 0.60)	<LOD	0.60 (0.51 - 0.69)	0.97 (0.83 - 1.1)	1.6 (1.3 - 1.8)
Females, 60–79	1	542	4.24	0.53 (0.44 - 0.64)	0.13[E] (<LOD - 0.23)	0.57 (0.45 - 0.68)	1.0 (0.83 - 1.2)	2.2[E] (1.1 - 3.3)
Females, 60–79	2	581	11.70	0.59 (0.52 - 0.66)	<LOD	0.64 (0.53 - 0.75)	1.1 (0.91 - 1.3)	2.4 (1.6 - 3.2)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.8.7

Lead (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5479	7.56	0.58 (0.53 - 0.63)	<LOD (<LOD - 0.27)	0.57 (0.51 - 0.63)	0.93 (0.85 - 1.0)	2.0 (1.7 - 2.2)
Total, 6–79	2	5719	16.28	0.48 (0.46 - 0.51)	<LOD	0.48 (0.46 - 0.51)	0.77 (0.68 - 0.86)	1.6 (1.4 - 1.8)
Males, Total 6–79	1	2653	5.88	0.54 (0.50 - 0.58)	0.23 (<LOD - 0.25)	0.53 (0.48 - 0.57)	0.86 (0.77 - 0.95)	1.8 (1.4 - 2.2)
Males, Total 6–79	2	2739	13.47	0.46 (0.43 - 0.48)	<LOD	0.45 (0.43 - 0.48)	0.70 (0.60 - 0.80)	1.5 (1.2 - 1.8)
Females, Total 6–79	1	2826	9.13	0.63 (0.56 - 0.70)	<LOD (<LOD - 0.28)	0.62 (0.54 - 0.70)	1.0 (0.88 - 1.1)	2.0 (1.6 - 2.4)
Females, Total 6–79	2	2980	18.86	0.51 (0.48 - 0.55)	<LOD	0.52 (0.47 - 0.57)	0.83 (0.72 - 0.94)	1.7 (1.5 - 1.8)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.8.8

Lead (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6291	16.48	0.49 (0.47 - 0.52)	<LOD	0.49 (0.46 - 0.52)	0.79 (0.71 - 0.87)	1.6 (1.5 - 1.8)
3–5[b]	1							
3–5	2	572	18.53	0.81 (0.71 - 0.93)	<LOD	0.83 (0.69 - 0.97)	1.2 (1.1 - 1.3)	2.7 (2.2 - 3.2)
6–11	1	1031	9.31	0.56 (0.51 - 0.61)	<LOD	0.54 (0.46 - 0.61)	0.81 (0.71 - 0.90)	1.6 (1.2 - 1.9)
6–11	2	1058	18.53	0.46 (0.43 - 0.50)	<LOD	0.48 (0.45 - 0.51)	0.70 (0.65 - 0.75)	1.3 (1.1 - 1.4)
12–19	1	982	10.18	0.34 (0.30 - 0.38)	<LOD	0.33 (0.30 - 0.37)	0.51 (0.44 - 0.57)	1.0 (0.72 - 1.3)
12–19	2	1039	19.06	0.31 (0.29 - 0.33)	<LOD	0.30 (0.28 - 0.33)	0.48 (0.43 - 0.54)	0.85 (0.68 - 1.0)
20–39	1	1165	9.53	0.45 (0.41 - 0.50)	<LOD (<LOD - 0.24)	0.45 (0.42 - 0.48)	0.69 (0.62 - 0.76)	1.3 (1.0 - 1.6)
20–39	2	1319	19.71	0.37 (0.34 - 0.40)	<LOD	0.35 (0.31 - 0.39)	0.57 (0.50 - 0.65)	1.1 (0.83 - 1.3)
40–59	1	1218	5.99	0.70 (0.63 - 0.78)	0.30 (<LOD - 0.34)	0.69 (0.61 - 0.77)	1.1 (0.93 - 1.2)	2.0 (1.6 - 2.4)
40–59	2	1223	13.65	0.57 (0.53 - 0.61)	<LOD	0.55 (0.50 - 0.59)	0.84 (0.71 - 0.98)	1.7 (1.4 - 2.1)
60–79	1	1083	3.14	0.93 (0.84 - 1.0)	0.41 (0.35 - 0.47)	0.93 (0.82 - 1.0)	1.4 (1.3 - 1.5)	2.8 (2.3 - 3.3)
60–79	2	1080	10.19	0.77 (0.71 - 0.83)	<LOD	0.80 (0.71 - 0.88)	1.1 (1.1 - 1.2)	2.1 (1.8 - 2.4)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.8.9

Lead (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	13.61	0.46 (0.44 - 0.49)	<LOD	0.46 (0.43 - 0.49)	0.73 (0.63 - 0.82)	1.5 (1.3 - 1.8)
Males, 6–11	1	522	6.90	0.57 (0.53 - 0.63)	<LOD (<LOD - 0.30)	0.57 (0.48 - 0.65)	0.84 (0.75 - 0.94)	1.7 (1.2 - 2.1)
Males, 6–11	2	530	17.55	0.43 (0.39 - 0.48)	<LOD	0.46 (0.42 - 0.49)	0.66 (0.61 - 0.72)	1.1 (0.97 - 1.3)
Males, 12–19	1	504	9.13	0.32 (0.29 - 0.36)	<LOD	0.31 (0.28 - 0.35)	0.50 (0.44 - 0.57)	0.96 (0.64 - 1.3)
Males, 12–19	2	541	17.01	0.30 (0.27 - 0.32)	<LOD	0.29 (0.25 - 0.32)	0.47 (0.37 - 0.57)	0.85 (0.59 - 1.1)
Males, 20–39	1	512	7.03	0.43 (0.38 - 0.49)	<LOD (<LOD - 0.26)	0.43 (0.40 - 0.47)	0.66 (0.57 - 0.75)	1.3^{E} (0.74 - 1.9)
Males, 20–39	2	550	14.91	0.35 (0.30 - 0.40)	<LOD	0.32 (0.24 - 0.39)	0.55 (0.44 - 0.66)	1.0^{E} (0.65 - 1.4)
Males, 40–59	1	574	4.70	0.62 (0.55 - 0.69)	0.29 (0.26 - 0.31)	0.60 (0.52 - 0.67)	0.93 (0.80 - 1.1)	1.8^{E} (1.1 - 2.5)
Males, 40–59	2	615	9.76	0.55 (0.51 - 0.59)	0.26 (<LOD - 0.32)	0.51 (0.45 - 0.56)	0.75 (0.61 - 0.88)	1.8 (1.2 - 2.5)
Males, 60–79	1	541	2.03	0.88 (0.82 - 0.96)	0.41 (0.39 - 0.44)	0.86 (0.77 - 0.96)	1.3 (1.1 - 1.5)	2.3 (1.5 - 3.1)
Males, 60–79	2	503	8.35	0.71 (0.65 - 0.77)	0.33 (<LOD - 0.40)	0.71 (0.61 - 0.81)	1.1 (1.0 - 1.1)	1.7 (1.4 - 2.0)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	19.15	0.52 (0.49 - 0.56)	<LOD	0.53 (0.48 - 0.58)	0.86 (0.75 - 0.96)	1.7 (1.5 - 1.9)
Females, 6–11	1	509	11.79	0.54 (0.47 - 0.61)	<LOD	0.53 (0.45 - 0.60)	0.79 (0.68 - 0.90)	1.5 (1.1 - 1.9)
Females, 6–11	2	528	19.51	0.50 (0.46 - 0.54)	<LOD	0.51 (0.47 - 0.54)	0.73 (0.65 - 0.81)	1.4^{E} (0.89 - 2.0)
Females, 12–19	1	478	11.30	0.36 (0.31 - 0.43)	<LOD (<LOD - 0.21)	0.35 (0.31 - 0.38)	0.52 (0.41 - 0.63)	1.1^{E} (0.52 - 1.6)
Females, 12–19	2	498	21.29	0.32 (0.29 - 0.35)	<LOD	0.32 (0.28 - 0.35)	0.49 (0.43 - 0.55)	0.86 (0.70 - 1.0)
Females, 20–39	1	653	11.49	0.48 (0.43 - 0.54)	<LOD (<LOD - 0.24)	0.46 (0.43 - 0.49)	0.72 (0.63 - 0.82)	1.4 (0.98 - 1.8)
Females, 20–39	2	769	23.15	0.39 (0.35 - 0.44)	<LOD	0.38 (0.32 - 0.44)	0.61 (0.51 - 0.70)	1.1 (0.84 - 1.3)
Females, 40–59	1	644	7.14	0.79 (0.69 - 0.90)	0.35 (<LOD - 0.43)	0.78 (0.68 - 0.88)	1.2 (0.98 - 1.4)	2.0 (1.4 - 2.7)
Females, 40–59	2	608	17.60	0.60 (0.52 - 0.68)	<LOD	0.60 (0.52 - 0.68)	0.94 (0.77 - 1.1)	1.6 (1.3 - 1.9)
Females, 60–79	1	542	4.24	0.97 (0.82 - 1.1)	0.41 (<LOD - 0.55)	0.99 (0.83 - 1.2)	1.5 (1.3 - 1.7)	3.0 (2.3 - 3.6)
Females, 60–79	2	577	11.79	0.83 (0.74 - 0.93)	<LOD	0.86 (0.75 - 0.96)	1.2 (1.0 - 1.4)	2.3 (1.8 - 2.8)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

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8.9 MANGANESE

Manganese (CASRN 7439-96-5) is the 12th most abundant element, occurring naturally in the Earth's crust at an average concentration of approximately 0.1% (Health Canada, 1987). Pure manganese is silver in colour, but manganese in the environment is always found combined with other elements in a variety of minerals. Manganese can exist in both organic and inorganic forms. Organic manganese compounds do not occur in nature but are manufactured for specific uses (ATSDR, 2008). Manganese is an essential trace element required for the maintenance of good health in humans.

Manganese is ubiquitous in the environment, naturally occurring in air, soil, water, and biological organisms, including food. Natural sources of manganese include erosion and volcanic activity (ATSDR, 2008). Manganese is released to the air from anthropogenic sources including mining operations, coke ovens, and iron, steel, and power plants. Historical use of a manganese-containing additive, methylcyclopentadienyl manganese tricarbonyl (MMT), in leaded gasoline has contributed to the atmospheric concentrations of manganese (ATSDR, 2008).

Metallic manganese is used principally in steel production to improve hardness and strength. Other uses of manganese compounds include production of dry-cell batteries, fireworks, matches, animal feed to supply essential trace minerals, porcelain and glass-bonding materials, and fertilizers. Potassium permanganate is commonly used in water and waste-treatment plants as a disinfectant and anti-algal agent, but is also used for metal cleaning, tanning, and bleaching (ATSDR, 2008). The predominant application of organic manganese was in petroleum refineries as an octane enhancer, namely MMT, in use prior to 2004 (Health Canada, 2010a). Other organic manganese compounds, such as maneb or mancozeb, are used as fungicides for fruits and vegetables and in seed treatment; maneb is no longer being registered for use in Canada (Health Canada, 2012). Another organic manganese compound, mangafodipir trisodium, is used as a contrast agent in magnetic resonance imaging (ATSDR, 2008).

Food is the main source of manganese exposure for the majority of the population (ATSDR, 2008). Manganese is found in trace amounts in all plant and animal tissues. Manganese intake from drinking water and air is substantially lower than intake from food (ATSDR, 2008).

The main routes of absorption for manganese are the respiratory and gastrointestinal tracts. Approximately 3% to 5% of orally ingested manganese is absorbed from the gastrointestinal tract and enters systemic circulation (ATSDR, 2008). Conversely, inhaled manganese enters systemic circulation directly, making the manganese available for distribution to and accumulation in body tissues, including the brain (Health Canada, 2010a). Half-lives are influenced by both age and route of exposure. The ubiquitous presence of manganese in foods along with the essential nature of this element has resulted in the development of homeostatic control mechanisms for dietary manganese. Under conditions of high dietary manganese, adaptive changes include reduced gastrointestinal absorption of manganese, enhanced manganese liver metabolism, and increased biliary and pancreatic excretion of manganese (Davis et al., 1993; Dorman et al., 2001; Dorman et al., 2002). Biliary excretion is the main excretory pathway with the manganese in bile being excreted in the feces along with unabsorbed dietary manganese (Davis et al., 1993; Malecki et al., 1996). Urinary excretion of manganese is low (Davis & Greger, 1992).

Concentrations in blood and urine can be used to evaluate exposure to manganese (ATSDR, 2008). Whole blood is preferred rather than plasma or serum because slight hemolysis of samples can significantly increase plasma or serum manganese concentrations (IOM, 2001). Concentrations in blood tend to reflect the overall body burden of manganese, whereas concentrations in urine are more stable responding only to significant fluctuations in manganese intake (IOM, 2001).

As an essential trace element, manganese is involved in the formation of bone, in cellular protection from free radical damage, and in amino acid, cholesterol, and carbohydrate metabolism (ATSDR, 2008; IOM, 2001). Manganese deficiency in humans is rare; however, excessive exposure can cause neurological effects (ATSDR, 2008).

The adverse health effects from overexposure to manganese depend on the route of exposure, the chemical form (solubility), the age of the individual at exposure, and the individual's nutritional status (iron content). Very high concentrations of manganese in air, such as those associated with occupational exposures, can result in metal fume fever, pneumonitis, and manganism (a condition resembling Parkinson's disease) (Health Canada, 1987). Exposure to moderately high levels of manganese in air can result in subtle neurological effects such as poorer fine-motor skills (Health Canada, 2010a). The United States Environmental Protection Agency has classified manganese as Group D, not classifiable as to human carcinogenicity, based on an absence of human data and inadequate animal data (EPA, 1996). The International Agency for Research on Cancer has not published an evaluation of the carcinogenicity of manganese (ITER, 2010).

Tolerable upper intake levels for manganese, which account for its potential toxicity, have been developed by the Institute of Medicine and adopted by Health Canada (Health Canada, 2010b; IOM, 2001). These levels only account for intake from pharmacological agents and do not include intake from diet. Manganese is included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply. An aesthetic objective for manganese in drinking water, based on palatability and the staining of laundry and plumbing fixtures, was established by Health Canada; this guideline was also deemed protective of adverse health effects (Health Canada, 1987). On the basis of health considerations, Health Canada has also established a manganese reference concentration in air (Health Canada, 2010a).

In a study carried out in British Columbia to assess the levels of trace elements in 61 non-smoking adults aged 30 to 65 years, the geometric mean and 95th percentile values of manganese in blood were 10.75 µg/L and 14.94 µg/L, respectively (Clark et al., 2007). In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric mean for manganese in whole blood was 9.33 µg/L (INSPQ, 2004). In a 1996 study of manganese levels in a non-occupationally exposed adult population in southwest province of Quebec, blood samples were obtained from 297 subjects between the age of 20 and 69 years (Baldwin et al., 1999). The geometric mean blood manganese level for this population was 7.1 µg/L. Blood manganese levels were also measured in children, aged 2 to 17 years, in Montréal (Dupont & Tanaka, 1985). Twenty-nine children were tested in 1976 and 24 children were tested in 1984 with mean blood manganese levels of 14.4 µg/L and 14.0 µg/L, respectively.

Manganese was measured in the whole blood and urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented in blood as µg/L (Tables 8.9.1, 8.9.2, and 8.9.3) and in urine as both µg/L (Tables 8.9.4, 8.9.5, and 8.9.6) and µg/g creatinine (Tables 8.9.7, 8.9.8, and 8.9.9). Finding a measurable amount of manganese in blood or urine is an indicator of exposure to manganese and does not necessarily mean that an adverse health effect will occur. Because manganese is an essential trace element, its presence in biological fluids is expected.

Table 8.9.1

Manganese — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5309	0	9.2 (9.0 - 9.5)	6.3 (6.1 - 6.5)	9.0 (8.8 - 9.3)	11 (10 - 11)	15 (15 - 16)
Total, 6–79	2	5575	0	9.8 (9.5 - 10)	6.6 (6.4 - 6.9)	9.5 (9.2 - 9.8)	11 (11 - 12)	15 (14 - 16)
Males, Total 6–79	1	2572	0	8.8 (8.5 - 9.0)	6.2 (5.8 - 6.5)	8.6 (8.4 - 8.9)	10 (9.7 - 10)	14 (13 - 15)
Males, Total 6–79	2	2687	0	9.3 (8.9 - 9.7)	6.3 (5.9 - 6.8)	9.1 (8.6 - 9.6)	11 (10 - 11)	14 (14 - 15)
Females, Total 6–79	1	2737	0	9.7 (9.4 - 9.9)	6.6 (6.3 - 6.8)	9.5 (9.2 - 9.8)	11 (11 - 12)	16 (15 - 17)
Females, Total 6–79	2	2888	0	10 (9.8 - 11)	7.0 (6.6 - 7.3)	9.8 (9.5 - 10)	12 (12 - 13)	16 (15 - 17)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.9.2

Manganese — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6070	0	9.8 (9.5 - 10)	6.7 (6.4 - 6.9)	9.5 (9.2 - 9.8)	12 (11 - 12)	15 (14 - 16)
3–5[b]	1							
3–5	2	495	0	11 (11 - 12)	7.6 (7.4 - 7.9)	11 (10 - 11)	13 (12 - 14)	18 (15 - 21)
6–11	1	907	0	9.9 (9.6 - 10)	6.9 (6.7 - 7.2)	9.7 (9.4 - 10)	11 (11 - 12)	16 (15 - 17)
6–11	2	961	0	11 (10 - 11)	7.7 (7.5 - 7.9)	11 (10 - 11)	12 (12 - 13)	16 (15 - 17)
12–19	1	942	0	10 (9.7 - 10)	6.7 (6.4 - 6.9)	9.9 (9.7 - 10)	12 (11 - 13)	16 (15 - 16)
12–19	2	997	0	10 (9.8 - 11)	7.0 (6.6 - 7.4)	9.9 (9.5 - 10)	12 (12 - 13)	16 (15 - 17)
20–39	1	1162	0	9.1 (8.8 - 9.5)	6.3 (6.0 - 6.5)	9.0 (8.7 - 9.3)	11 (10 - 11)	16 (15 - 17)
20–39	2	1313	0	9.8 (9.3 - 10)	6.4 (5.8 - 7.0)	9.7 (9.2 - 10)	12 (11 - 12)	16 (14 - 17)
40–59	1	1219	0	9.1 (8.8 - 9.5)	6.4 (6.1 - 6.7)	8.9 (8.5 - 9.3)	10 (10 - 11)	15 (13 - 16)
40–59	2	1222	0	9.7 (9.2 - 10)	6.7 (6.4 - 7.0)	9.2 (8.7 - 9.7)	11 (11 - 12)	15 (14 - 16)
60–79	1	1079	0	8.8 (8.6 - 9.1)	5.9 (5.5 - 6.3)	8.8 (8.4 - 9.2)	10 (10 - 11)	14 (13 - 15)
60–79	2	1082	0	9.4 (9.1 - 9.7)	6.5 (6.3 - 6.7)	8.9 (8.6 - 9.2)	11 (10 - 12)	15 (14 - 15)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.9.3

Manganese — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2940	0	9.4 (9.0 - 9.8)	6.4 (5.9 - 6.8)	9.1 (8.6 - 9.6)	11 (11 - 11)	14 (14 - 15)
Males, 6–11	1	458	0	9.5 (9.1 - 9.9)	6.6 (6.0 - 7.1)	9.3 (8.9 - 9.7)	11 (11 - 12)	15 (12 - 18)
Males, 6–11	2	488	0	10 (10 - 11)	7.5 (7.1 - 7.8)	10 (9.6 - 11)	12 (11 - 13)	15 (13 - 16)
Males, 12–19	1	489	0	9.4 (9.0 - 9.9)	6.5 (6.2 - 6.7)	9.4 (9.0 - 9.9)	11 (9.9 - 12)	14 (14 - 15)
Males, 12–19	2	523	0	9.8 (9.4 - 10)	6.7 (6.2 - 7.2)	9.5 (9.1 - 10)	12 (11 - 12)	15 (13 - 17)
Males, 20–39	1	511	0	8.6 (8.3 - 8.9)	6.2 (5.9 - 6.5)	8.4 (8.0 - 8.8)	10 (9.7 - 10)	13 (12 - 14)
Males, 20–39	2	552	0	9.0 (8.3 - 9.8)	5.9 (5.1 - 6.7)	9.0 (8.0 - 10)	11 (10 - 11)	14 (13 - 15)
Males, 40–59	1	577	0	8.8 (8.4 - 9.2)	6.2 (5.6 - 6.9)	8.7 (8.2 - 9.1)	10 (9.7 - 10)	14 (12 - 15)
Males, 40–59	2	617	0	9.3 (8.8 - 9.9)	6.6 (6.1 - 7.2)	9.0 (8.4 - 9.5)	11 (10 - 12)	14 (13 - 15)
Males, 60–79	1	537	0	8.4 (8.1 - 8.8)	5.6 (5.3 - 5.9)	8.2 (7.7 - 8.7)	10 (9.6 - 10)	14 (13 - 15)
Males, 60–79	2	507	0	9.2 (9.0 - 9.5)	6.3 (6.0 - 6.6)	8.7 (8.3 - 9.0)	11 (10 - 11)	15 (14 - 16)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3130	0	10 (9.9 - 11)	7.0 (6.7 - 7.3)	9.9 (9.5 - 10)	12 (12 - 13)	16 (15 - 17)
Females, 6–11	1	449	0	10 (10 - 11)	7.4 (6.9 - 7.8)	10 (9.7 - 10)	12 (11 - 12)	16 (15 - 17)
Females, 6–11	2	473	0	11 (11 - 12)	8.0 (7.6 - 8.4)	11 (10 - 11)	13 (12 - 13)	16 (15 - 18)
Females, 12–19	1	453	0	11 (10 - 11)	7.1 (6.6 - 7.7)	10 (9.9 - 11)	13 (12 - 14)	17 (16 - 18)
Females, 12–19	2	474	0	11 (10 - 11)	7.4 (6.9 - 7.9)	10 (9.8 - 11)	12 (12 - 13)	17 (16 - 18)
Females, 20–39	1	651	0	9.8 (9.2 - 10)	6.5 (6.0 - 7.0)	9.5 (8.9 - 10)	12 (11 - 12)	17 (15 - 19)
Females, 20–39	2	761	0	11 (9.9 - 11)	7.2 (6.7 - 7.8)	10 (9.5 - 11)	12 (11 - 14)	16 (15 - 17)
Females, 40–59	1	642	0	9.5 (9.0 - 10)	6.4 (6.1 - 6.8)	9.2 (8.6 - 9.8)	11 (10 - 12)	16 (13 - 18)
Females, 40–59	2	605	0	10 (9.5 - 11)	6.8 (6.3 - 7.2)	9.6 (8.8 - 10)	12 (11 - 13)	16 (15 - 17)
Females, 60–79	1	542	0	9.2 (9.0 - 9.5)	6.6 (6.3 - 6.9)	9.4 (9.0 - 9.8)	11 (10 - 11)	14 (13 - 15)
Females, 60–79	2	575	0	9.5 (9.1 - 10)	6.6 (6.4 - 6.9)	9.1 (8.7 - 9.5)	11 (10 - 12)	14 (13 - 16)

[a] Breakdown by sex for the 3–5 year old age group is not recommended.

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[c] Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.9.4

Manganese — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5431	35.54	0.081 (0.072 - 0.092)	<LOD	0.079 (0.067 - 0.091)	0.12 (0.087 - 0.15)	0.37 (0.32 - 0.43)
Total, 6–79	2	5738	70.83	—	<LOD	<LOD	<LOD	0.36 (0.32 - 0.40)
Males, Total 6–79	1	2639	38.16	0.078 (0.068 - 0.089)	<LOD	0.073 (0.060 - 0.087)	0.11 (0.074 - 0.14)	0.37 (0.29 - 0.46)
Males, Total 6–79	2	2746	75.82	—	<LOD	<LOD	<LOD	0.30 (0.27 - 0.33)
Females, Total 6–79	1	2792	33.06	0.085 (0.076 - 0.095)	<LOD	0.085 (0.074 - 0.095)	0.13 (0.10 - 0.16)	0.37 (0.33 - 0.41)
Females, Total 6–79	2	2992	66.24	—	<LOD	<LOD	<LOD (<LOD - 0.20)	0.41 (0.32 - 0.50)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.9.5

Manganese — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6309	70.41	—	<LOD	<LOD	<LOD	0.36 (0.32 - 0.40)
3–5[b]	1							
3–5	2	571	66.20	—	<LOD	<LOD	<LOD (<LOD - 0.23)	0.54[E] (0.30 - 0.77)
6–11	1	1032	38.08	0.082 (0.073 - 0.092)	<LOD	0.077 (0.063 - 0.090)	0.12 (0.094 - 0.15)	0.41 (0.32 - 0.49)
6–11	2	1062	68.17	—	<LOD	<LOD	<LOD (<LOD - 0.22)	0.42 (0.35 - 0.50)
12–19	1	981	32.31	0.088 (0.079 - 0.098)	<LOD	0.089 (0.082 - 0.096)	0.13 (0.10 - 0.16)	0.37 (0.30 - 0.45)
12–19	2	1041	67.63	—	<LOD	<LOD	<LOD (<LOD - 0.20)	0.39 (0.31 - 0.46)
20–39	1	1153	38.16	0.079 (0.068 - 0.092)	<LOD	0.075 (0.060 - 0.090)	0.12 (0.081 - 0.16)	0.38 (0.30 - 0.47)
20–39	2	1321	72.90	—	<LOD	<LOD	<LOD	0.32 (0.28 - 0.37)
40–59	1	1203	35.91	0.081 (0.068 - 0.095)	<LOD	0.079 (0.063 - 0.094)	0.11 (0.076 - 0.15)	0.35 (0.28 - 0.42)
40–59	2	1228	74.02	—	<LOD	<LOD	<LOD	0.36 (0.29 - 0.42)
60–79	1	1062	32.77	0.082 (0.073 - 0.092)	<LOD	0.078 (0.065 - 0.090)	0.12 (0.087 - 0.15)	0.38 (0.29 - 0.46)
60–79	2	1086	70.35	—	<LOD	<LOD	<LOD	0.38 (0.33 - 0.44)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

■ Table 8.9.6

Manganese — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	75.66	—	<LOD	<LOD	<LOD	0.30 (0.27 - 0.33)
Males, 6–11	1	524	39.89	0.078 (0.070 - 0.087)	<LOD	0.073 (0.065 - 0.081)	0.10 (0.071 - 0.13)	0.39 (0.27 - 0.50)
Males, 6–11	2	532	75.38	—	<LOD	<LOD	<LOD	0.32 (0.24 - 0.39)
Males, 12–19	1	505	35.25	0.079 (0.069 - 0.091)	<LOD	0.078 (0.062 - 0.094)	0.11 (0.077 - 0.14)	0.36 (0.24 - 0.48)
Males, 12–19	2	542	73.43	—	<LOD	<LOD	<LOD	0.25 (<LOD - 0.31)
Males, 20–39	1	510	40.20	—	<LOD	0.073 (0.051 - 0.095)	0.11[E] (0.056 - 0.17)	0.44[E] (0.26 - 0.62)
Males, 20–39	2	551	75.86	—	<LOD	<LOD	<LOD	0.30 (0.24 - 0.37)
Males, 40–59	1	572	38.64	0.077 (0.064 - 0.094)	<LOD	0.073 (0.053 - 0.093)	0.11 (0.074 - 0.14)	0.33 (0.22 - 0.44)
Males, 40–59	2	616	77.27	—	<LOD	<LOD	<LOD	0.28 (0.23 - 0.32)
Males, 60–79	1	528	36.74	0.076 (0.061 - 0.094)	<LOD	0.072 (0.051 - 0.092)	0.10[E] (0.061 - 0.14)	0.35[E] (0.20 - 0.49)
Males, 60–79	2	505	77.03	—	<LOD	<LOD	<LOD	0.35 (0.29 - 0.42)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3273	65.54	—	<LOD	<LOD	<LOD (<LOD - 0.20)	0.42 (0.32 - 0.52)
Females, 6–11	1	508	36.22	0.086 (0.073 - 0.10)	<LOD	0.084 (0.061 - 0.11)	0.14 (0.10 - 0.19)	0.43 (0.31 - 0.54)
Females, 6–11	2	530	60.94	—	<LOD	<LOD	0.24 (0.20 - 0.28)	0.62[E] (0.33 - 0.92)
Females, 12–19	1	476	29.20	0.098 (0.087 - 0.11)	<LOD	0.093 (0.089 - 0.096)	0.15 (0.12 - 0.17)	0.38 (0.29 - 0.48)
Females, 12–19	2	499	61.32	—	<LOD	<LOD	<LOD (<LOD - 0.22)	0.49[E] (0.25 - 0.73)
Females, 20–39	1	643	36.55	0.080 (0.068 - 0.094)	<LOD	0.077 (0.059 - 0.096)	0.12 (0.090 - 0.16)	0.35 (0.28 - 0.43)
Females, 20–39	2	770	70.78	—	<LOD	<LOD	<LOD	0.34 (0.29 - 0.40)
Females, 40–59	1	631	33.44	0.084 (0.070 - 0.10)	<LOD	0.083 (0.071 - 0.096)	0.12[E] (0.071 - 0.17)	0.37 (0.28 - 0.45)
Females, 40–59	2	612	70.75	—	<LOD	<LOD	<LOD (<LOD - 0.22)	0.43[E] (0.24 - 0.62)
Females, 60–79	1	534	28.84	0.088 (0.077 - 0.10)	<LOD	0.086 (0.067 - 0.10)	0.13 (0.096 - 0.17)	0.39[E] (0.22 - 0.56)
Females, 60–79	2	581	64.54	—	<LOD	<LOD	<LOD	0.42[E] (0.22 - 0.62)

[a] Breakdown by sex for the 3–5 year old age group is not recommended.

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[c] Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

[E] Use data with caution.

Table 8.9.7

Manganese (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5418	35.62	0.097 (0.085 - 0.11)	<LOD	0.091 (0.081 - 0.10)	0.19 (0.15 - 0.23)	0.70 (0.57 - 0.83)
Total, 6–79	2	5719	71.06	—	<LOD	<LOD	<LOD	0.61 (0.51 - 0.70)
Males, Total 6–79	1	2630	38.29	0.075 (0.065 - 0.087)	<LOD	0.073 (0.062 - 0.084)	0.14 (0.10 - 0.17)	0.48 (0.34 - 0.62)
Males, Total 6–79	2	2739	76.01	—	<LOD	<LOD	<LOD	0.42 (0.34 - 0.51)
Females, Total 6–79	1	2788	33.11	0.12 (0.11 - 0.14)	<LOD	0.11 (0.10 - 0.13)	0.24 (0.21 - 0.27)	0.84 (0.70 - 0.99)
Females, Total 6–79	2	2980	66.51	—	<LOD	<LOD	<LOD (<LOD - 0.26)	0.72 (0.63 - 0.81)

[a] For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.9.8

Manganese (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6289	70.63	—	<LOD	<LOD	<LOD	0.61 (0.53 - 0.68)
3–5[b]	1							
3–5	2	570	66.32	—	<LOD	<LOD	<LOD (<LOD - 0.52)	1.2 (0.81 - 1.5)
6–11	1	1029	38.19	0.12 (0.11 - 0.14)	<LOD	0.11 (0.091 - 0.12)	0.23 (0.18 - 0.28)	0.82 (0.66 - 0.99)
6–11	2	1058	68.43	—	<LOD	<LOD	<LOD (<LOD - 0.25)	0.69 (0.55 - 0.82)
12–19	1	980	32.35	0.076 (0.064 - 0.090)	<LOD	0.071 (0.055 - 0.087)	0.14 (0.10 - 0.17)	0.49[E] (0.31 - 0.67)
12–19	2	1039	67.76	—	<LOD	<LOD	<LOD (<LOD - 0.18)	0.39 (0.26 - 0.53)
20–39	1	1149	38.29	0.086 (0.075 - 0.10)	<LOD	0.081 (0.070 - 0.091)	0.17 (0.13 - 0.22)	0.61[E] (0.38 - 0.85)
20–39	2	1319	73.01	—	<LOD	<LOD	<LOD	0.58 (0.40 - 0.76)
40–59	1	1198	36.06	0.10 (0.085 - 0.12)	<LOD	0.093 (0.081 - 0.10)	0.19 (0.14 - 0.24)	0.78 (0.57 - 0.99)
40–59	2	1223	74.33	—	<LOD	<LOD	<LOD	0.70[E] (0.42 - 0.99)
60–79	1	1062	32.77	0.11 (0.10 - 0.13)	<LOD	0.11 (0.095 - 0.12)	0.23 (0.21 - 0.25)	0.76 (0.62 - 0.91)
60–79	2	1080	70.74	—	<LOD	<LOD	<LOD	0.61 (0.51 - 0.70)

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[b] Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

[E] Use data with caution.

Table 8.9.9

Manganese (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	75.86	—	<LOD	<LOD	<LOD	0.44 (0.35 - 0.53)
Males, 6–11	1	522	40.04	—	<LOD	0.10 (0.082 - 0.12)	0.21 (0.16 - 0.26)	0.73 (0.49 - 0.98)
Males, 6–11	2	530	75.66	—	<LOD	<LOD	<LOD	0.38 (0.28 - 0.48)
Males, 12–19	1	504	35.32	0.066 (0.055 - 0.078)	<LOD	0.064 (0.051 - 0.077)	0.12 (0.097 - 0.14)	0.31^E (0.15 - 0.47)
Males, 12–19	2	541	73.57	—	<LOD	<LOD	<LOD	0.26 (<LOD - 0.30)
Males, 20–39	1	508	40.35	—	<LOD	0.070 (0.055 - 0.086)	0.13^E (0.075 - 0.19)	0.42^E (0.22 - 0.63)
Males, 20–39	2	550	76.00	—	<LOD	<LOD	<LOD	0.44^E (0.22 - 0.66)
Males, 40–59	1	568	38.91	0.076 (0.061 - 0.094)	<LOD	0.072 (0.052 - 0.091)	0.13 (0.092 - 0.17)	0.55^E (0.23 - 0.86)
Males, 40–59	2	615	77.40	—	<LOD	<LOD	<LOD	0.47 (0.31 - 0.63)
Males, 60–79	1	528	36.74	0.079 (0.064 - 0.096)	<LOD	0.074 (0.056 - 0.091)	0.15 (0.10 - 0.20)	0.44 (0.31 - 0.56)
Males, 60–79	2	503	77.34	—	<LOD	<LOD	<LOD	0.49 (0.34 - 0.63)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3261	65.78	—	<LOD	<LOD	<LOD (<LOD - 0.27)	0.74 (0.62 - 0.86)
Females, 6–11	1	507	36.29	0.13 (0.11 - 0.15)	<LOD	0.12 (0.094 - 0.14)	0.26 (0.21 - 0.31)	0.85 (0.66 - 1.1)
Females, 6–11	2	528	61.17	—	<LOD	<LOD	0.29 (0.26 - 0.32)	0.78 (0.57 - 1.0)
Females, 12–19	1	476	29.20	0.088 (0.072 - 0.11)	<LOD	0.084 (0.064 - 0.10)	0.15 (0.11 - 0.19)	0.62 (0.43 - 0.82)
Females, 12–19	2	498	61.45	—	<LOD	<LOD	<LOD (<LOD - 0.24)	0.56 (0.47 - 0.65)
Females, 20–39	1	641	36.66	0.11 (0.088 - 0.13)	<LOD	0.10 (0.084 - 0.12)	0.21 (0.16 - 0.26)	0.73^E (0.22 - 1.2)
Females, 20–39	2	769	70.87	—	<LOD	<LOD	<LOD	0.61 (0.42 - 0.79)
Females, 40–59	1	630	33.49	0.14 (0.12 - 0.16)	<LOD	0.12 (0.095 - 0.14)	0.26 (0.20 - 0.32)	0.87 (0.70 - 1.0)
Females, 40–59	2	608	71.22	—	<LOD	<LOD	<LOD (<LOD - 0.29)	0.92^E (0.52 - 1.3)
Females, 60–79	1	534	28.84	0.16 (0.13 - 0.19)	<LOD	0.15 (0.12 - 0.18)	0.27 (0.23 - 0.31)	1.1^E (0.56 - 1.6)
Females, 60–79	2	577	64.99	—	<LOD	<LOD	<LOD (<LOD - 0.32)	0.66 (0.45 - 0.88)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

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8.10 MERCURY

Mercury (CASRN 7439-97-6) is a naturally occurring soft, silvery white metal present in the Earth's crust at an average concentration of approximately 0.000005% (Emsley, 2001). It is the only metal that is a liquid at room temperature. Mercury exists in elemental, inorganic, and organic forms (CCME, 1999). Elemental and certain organic forms of mercury have relatively high vapour pressures and, as a result, can be present as a vapour in air (ATSDR, 1999). The most common organic mercury compounds in nature are methylmercury (monomethylmercury) and dimethylmercury. Mercury can be converted among its elemental, inorganic, and organic forms by a variety of processes including biological transformation (Environment Canada, 2010).

Mercury is found throughout the environment, including remote Arctic regions because of its persistence, mobility, and tendency to accumulate in colder climates. Natural sources include volcanic activity and natural erosion of mercury-containing deposits (Environment Canada & Health Canada, 2010). Metabolism of inorganic mercury by microorganisms in the environment creates organic mercury (methylmercury) that can bioaccumulate in terrestrial and aquatic food chains (ATSDR, 1999). Anthropogenic sources of inorganic mercury include metal mining and smelting; combustion of fossil fuels, particularly coal; incineration of municipal wastes; cement production; and sewage sludge and waste water (UNEP, 2002). Inorganic mercury may also be released to the environment following disposal of products containing mercury.

Mercury has unique properties that have made it useful in certain products such as wiring devices, switches, and scientific measuring devices including vacuum gauges and thermometers (ATSDR, 1999). Today it has been phased out of most products manufactured in Canada; however, many products that contain mercury are still imported into the Canadian marketplace (Canada, 2011a). Inorganic mercury is still found in some medical devices, such as thermostats and X-ray tubes, and in button-cell batteries used in small electronic and hearing aids. Mercury vapour is also present in many lamps and lights including all fluorescent lamps, mercury vapour lamps, metal halide lamps, and sodium vapour lamps (Environment Canada, 2010). Use of mercury-containing light bulbs is increasing because of widespread replacement of incandescent bulbs with compact fluorescent bulbs. Mercury is also used as an industrial catalyst and in laboratory reagents, disinfectants, embalming solutions, and some pharmaceuticals. A significant use of inorganic mercury is in dental amalgam, which is composed of approximately 50% mercury, but it contributes only minimally to the total daily exposure of Canadians to mercury (Health Canada, 2007; IMERC, 2010).

Mercury exposure for the general population is primarily due to methylmercury, and occurs through the consumption of fish and seafood (Health Canada, 2007). To a much lesser extent, the general population is exposed to inorganic mercury from such sources as dental amalgams (Health Canada, 2007). The general population may also be exposed to elemental mercury via inhalation of vapours in ambient air, ingestion of drinking water and food, or through dental and medical treatments (ATSDR, 1999).

Approximately 95% of organic mercury is absorbed from the gastrointestinal tract following oral ingestion, whereas elemental mercury is poorly absorbed through the digestive tract or the skin (ATSDR, 1999). Following absorption, organic mercury is distributed to all tissues, including hair, with highest accumulation in the kidneys (ATSDR, 1999). Organic mercury is demethylated in the body to inorganic mercury that accumulates primarily in the liver and kidneys. Previous studies have shown that inorganic mercury constitutes 14% to 26% of total blood mercury (Kingman et al., 1998; Oskarsson et al., 1996; Passos et al., 2007). Methylmercury is estimated to have a biological half-life of approximately 50 days. The majority of mercury in the body is excreted via feces, with a small amount excreted as inorganic mercury in urine (ATSDR, 1999).

Exposure to mercury is commonly evaluated using mercury concentrations in blood and urine, although hair also may be used as a biomarker of exposure (ATSDR, 1999). Blood concentrations primarily reflect recent exposures to mercury (ATSDR, 1999). Typically, blood and urine mercury levels are reported as total mercury comprising both inorganic and organic mercury. The concentration of total mercury in blood is accepted as a reasonable measure of methylmercury exposure. Based on a review of existing data from other countries, the World Health Organization has estimated that the average total blood mercury concentration for the general population is approximately 8 µg/L (WHO, 1990). In individuals who consume fish daily, methylmercury concentrations in blood can be as high as 200 µg/L (WHO, 1990).

Mercury is known to be toxic to humans with the effects depending on the form and the exposure route. Chronic oral exposure to low levels of methylmercury may not result in any observable symptoms (Health Canada, 2007). The primary effects associated with oral exposure to organic mercury compounds are neurological effects and developmental neurotoxicity (UNEP, 2002). Symptoms of organic mercury toxicity include a tingling sensation in the extremities; impaired peripheral vision, hearing, taste, and smell; slurred speech; muscle weakness and an unsteady gait; irritability; memory loss; depression; and sleeping difficulties (UNEP, 2002). Exposure of a fetus or young child to organic mercury can result in effects on the development of the nervous system, affecting fine-motor function, attention, verbal learning, and memory (ATSDR, 1999; Health Canada, 2007). Exposure to elemental mercury may be hazardous, depending upon the levels of exposure, because the vapour that can be released from this form is readily absorbed into the body through inhalation. Inhalation of mercury vapour may cause respiratory, cardiovascular, kidney, and neurological effects. Exposure to inorganic mercury from dental amalgams has not been associated with neurologic effects in children or adults (Bates et al., 2004; Bellinger et al., 2007; DeRouen et al., 2006; Factor-Litvak et al., 2003). Health Canada concluded that mercury exposure from dental amalgams does not pose a health impact for the general population (Health Canada, 1996).

The International Agency for Research on Cancer (IARC) determined that methylmercury compounds are possibly carcinogenic to humans (Group 2B), based on animal data showing a link to certain cancers, particularly renal cancer (IARC, 1993). Elemental mercury and inorganic mercury compounds were classified by IARC as Group 3, not classifiable as to their carcinogenicity to humans (IARC, 1993).

The United Nations Environment Programme (UNEP) *Global Risk Assessment for Mercury* concluded that there was sufficient evidence of adverse impacts from mercury to warrant further international action to reduce the risks to human health and the environment (UNEP, 2002). International negotiations are taking place under UNEP toward a global legally binding instrument, the intent of which is to reduce atmospheric emissions, supply, trade, and demand for mercury, and to find environmentally sound solutions for storage of mercury and mercury-containing wastes.

In Canada, mercury and its compounds are listed as toxic substances on Schedule 1 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; Canada, 2012a). Existing and planned actions to manage the risks from mercury are summarized in the Government of Canada's *Risk Management Strategy for Mercury* (Environment Canada & Health Canada, 2010). These risk management actions include several Canada-wide standards that have been established to reduce the releases of mercury to the environment (CCME, 2000; CCME, 2005; CCME, 2006; CCME, 2007).

The *Surface Coating Materials Regulations*, in effect under the *Canada Consumer Product Safety Act*, restrict the level of mercury in all surface coating materials advertised, sold or imported into Canada (Canada, 2005). In addition, the *Toys Regulations* prohibit any compound of mercury in the surface coating material that is applied to a product that is used by a child in learning or play situations (Canada, 2011b). In 2011, a regulation was proposed under CEPA 1999 with prohibitions on the import, manufacture, sale, and offer for sale of mercury-containing products that are not currently regulated under other legislation (Canada, 2011a). Mercury and its compounds are also included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011). The *Food and Drug Regulations* prohibit sale in Canada of drugs for human use containing mercury or any of its salts or derivatives except in some specific instances, including those where it is present as a preservative (Canada, 2012b).

On the basis of health considerations, Health Canada has developed a Canadian drinking water quality guideline that sets out the maximum acceptable concentration of mercury (Health Canada, 1986; Health Canada, 2012a). Health Canada has also adopted a provisional tolerable daily mercury intake level for adults developed by the World Health Organization (WHO, 1972). For women who are or may become pregnant and for young children, Health Canada has developed a provisional tolerable daily intake level for mercury (Health Canada, 2002; Health Canada, 2007). Health Canada has also established a total mercury blood guidance value of 20 µg/L for the general adult population (Health Canada, 2004). For children (<18 years of age), pregnant women, and women of childbearing age (<50 years of age), a provisional methylmercury guidance value of 8 µg/L has recently been proposed for the protection of the developing nervous system (Legrand et al., 2010). Health Canada has also established maximum contaminant concentrations for mercury in fish (Health Canada, 2012b) and provides consumption advice for consumers (Health Canada, 2008).

In a study carried out in British Columbia to assess the levels of trace elements in 61 non-smoking adults aged 30 to 65 years, the geometric mean and 95th percentile concentrations of total mercury in blood were 2.94 µg/L and 7.26 µg/L, respectively (Clark et al., 2007). In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric mean of total mercury in whole blood was 0.74 µg/L (INSPQ, 2004).

Total mercury was measured in the whole blood of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented in blood as µg/L (Tables 8.10.1, 8.10.2, and 8.10.3). Finding a measurable amount of mercury in blood is an indicator of exposure to mercury and does not necessarily mean that an a dverse health effect will occur.

Table 8.10.1

Mercury (total) — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5319	11.64	0.69 (0.55 - 0.86)	<LOD	0.81 (0.64 - 0.97)	1.5 (1.1 - 2.0)	4.6^{E} (2.5 - 6.7)
Total, 6–79	2	5575	14.28	0.72 (0.57 - 0.90)	<LOD	0.77 (0.57 - 0.96)	1.7 (1.3 - 2.2)	5.6^{E} (3.3 - 7.8)
Males, Total 6–79	1	2576	12.11	0.68 (0.55 - 0.84)	<LOD	0.79 (0.64 - 0.94)	1.6 (1.1 - 2.0)	5.1^{E} (2.6 - 7.5)
Males, Total 6–79	2	2687	14.77	0.74 (0.58 - 0.95)	<LOD	0.80 (0.56 - 1.0)	2.0 (1.5 - 2.5)	6.3^{E} (2.9 - 9.8)
Females, Total 6–79	1	2743	11.19	0.70 (0.56 - 0.88)	<LOD^{E} (<LOD - 0.11)	0.82 (0.63 - 1.0)	1.5 (1.1 - 1.9)	4.4^{E} (2.5 - 6.3)
Females, Total 6–79	2	2888	13.82	0.69 (0.55 - 0.86)	<LOD	0.74 (0.56 - 0.92)	1.6 (1.2 - 2.0)	5.1^{E} (3.0 - 7.2)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.10.2

Mercury (total) — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6070	15.55	0.70 (0.56 - 0.87)	<LOD	0.74 (0.55 - 0.93)	1.7 (1.3 - 2.1)	5.5^{E} (3.3 - 7.6)
3–5[b]	1							
3–5	2	495	29.90	0.27 (0.20 - 0.37)	<LOD	0.20^{E} (0.11 - 0.28)	F	3.0^{E} (1.7 - 4.3)
6–11	1	910	24.84	0.26 (0.22 - 0.32)	<LOD	0.24 (0.18 - 0.29)	0.66 (0.47 - 0.85)	2.1^{E} (1.3 - 2.9)
6–11	2	961	29.03	0.28 (0.22 - 0.34)	<LOD	0.21^{E} (0.11 - 0.30)	0.62 (0.47 - 0.78)	2.0 (1.3 - 2.6)
12–19	1	945	20.85	0.30 (0.23 - 0.40)	<LOD	0.28 (0.20 - 0.37)	0.76^{E} (0.47 - 1.0)	2.2^{E} (0.88 - 3.5)
12–19	2	997	26.58	0.27 (0.20 - 0.35)	<LOD	0.20^{E} (0.10 - 0.29)	0.62 (0.48 - 0.76)	2.4^{E} (1.3 - 3.5)
20–39	1	1165	8.76	0.65 (0.52 - 0.81)	<LOD	0.76 (0.61 - 0.91)	1.4^{E} (0.88 - 2.0)	4.7^{E} (2.4 - 7.1)
20–39	2	1313	10.05	0.64 (0.47 - 0.86)	<LOD	0.65 (0.43 - 0.86)	1.6 (1.1 - 2.2)	5.2^{E} (2.6 - 7.8)
40–59	1	1220	3.52	1.0 (0.80 - 1.3)	0.21^{E} (0.12 - 0.30)	1.1 (0.83 - 1.3)	1.9 (1.4 - 2.3)	6.4^{E} (3.0 - 9.8)
40–59	2	1222	5.16	1.0 (0.79 - 1.3)	0.19 (0.17 - 0.21)	1.1 (0.86 - 1.3)	2.1 (1.6 - 2.6)	7.3^{E} (2.4 - 12)
60–79	1	1079	4.73	0.86 (0.64 - 1.2)	F	0.96 (0.75 - 1.2)	1.9 (1.2 - 2.5)	4.8^{E} (2.7 - 6.9)
60–79	2	1082	5.27	1.1 (0.86 - 1.5)	0.19^{E} (0.11 - 0.28)	1.2 (0.93 - 1.5)	2.3 (1.7 - 2.8)	6.5^{E} (3.9 - 9.2)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.10.3

Mercury (total) — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2940	16.16	0.72 (0.56 - 0.92)	<LOD	0.77 (0.53 - 1.0)	1.9 (1.5 - 2.4)	6.1^{E} (2.7 - 9.5)
Males, 6–11	1	459	26.14	0.24 (0.19 - 0.32)	<LOD	0.21^{E} (0.12 - 0.30)	0.62 (0.40 - 0.84)	2.0^{E} (0.91 - 3.1)
Males, 6–11	2	488	29.71	0.24 (0.19 - 0.31)	<LOD	0.19 (0.16 - 0.23)	0.54 (0.41 - 0.68)	1.9^{E} (0.91 - 2.9)
Males, 12–19	1	489	20.65	0.28^{E} (0.19 - 0.41)	<LOD	0.25^{E} (0.15 - 0.35)	0.64^{E} (0.21 - 1.1)	F
Males, 12–19	2	523	26.96	0.26 (0.18 - 0.36)	<LOD	0.19^{E} (<LOD - 0.29)	0.62 (0.41 - 0.83)	2.6^{E} (1.5 - 3.8)
Males, 20–39	1	514	9.34	0.61 (0.47 - 0.80)	<LOD	0.72 (0.55 - 0.89)	1.5^{E} (0.66 - 2.2)	4.6^{E} (2.6 - 6.6)
Males, 20–39	2	552	10.51	0.62 (0.45 - 0.84)	<LOD	0.62 (0.43 - 0.81)	1.7^{E} (1.0 - 2.4)	4.7^{E} (2.2 - 7.1)
Males, 40–59	1	577	3.47	1.0 (0.82 - 1.3)	0.24^{E} (0.13 - 0.34)	1.0 (0.81 - 1.2)	1.8 (1.5 - 2.1)	F
Males, 40–59	2	617	4.54	1.2 (0.91 - 1.7)	0.20^{E} (<LOD - 0.30)	1.2 (0.99 - 1.4)	2.7^{E} (1.6 - 3.8)	F
Males, 60–79	1	537	4.28	0.97 (0.70 - 1.3)	0.17^{E} (<LOD - 0.26)	1.0 (0.67 - 1.3)	2.1 (1.5 - 2.7)	F
Males, 60–79	2	507	4.93	1.1 (0.84 - 1.5)	0.19^{E} (<LOD - 0.29)	1.3 (0.94 - 1.6)	2.3 (1.6 - 2.9)	7.0^{E} (3.9 - 10)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3130	14.98	0.67 (0.54 - 0.84)	<LOD	0.71 (0.54 - 0.88)	1.6 (1.2 - 2.0)	5.1^{E} (3.0 - 7.1)
Females, 6–11	1	451	23.50	0.29 (0.24 - 0.35)	<LOD	0.25 (0.20 - 0.30)	0.78 (0.54 - 1.0)	2.2^{E} (1.1 - 3.2)
Females, 6–11	2	473	28.33	0.32 (0.24 - 0.42)	<LOD	0.31^{E} (0.17 - 0.46)	0.71^{E} (0.44 - 0.98)	2.1 (1.4 - 2.7)
Females, 12–19	1	456	21.05	0.33 (0.26 - 0.41)	<LOD	0.32 (0.22 - 0.43)	0.83 (0.61 - 1.0)	2.2^{E} (1.3 - 3.1)
Females, 12–19	2	474	26.16	0.28 (0.21 - 0.38)	<LOD	0.21^{E} (<LOD - 0.34)	0.62 (0.46 - 0.78)	F
Females, 20–39	1	651	8.29	0.69 (0.53 - 0.91)	0.11^{E} (<LOD - 0.15)	0.80 (0.59 - 1.0)	1.4 (0.91 - 1.9)	4.8^{E} (2.0 - 7.5)
Females, 20–39	2	761	9.72	0.66 (0.47 - 0.92)	<LOD	0.69^{E} (0.39 - 1.0)	1.6 (1.1 - 2.1)	F
Females, 40–59	1	643	3.58	0.99 (0.76 - 1.3)	0.19^{E} (<LOD - 0.29)	1.1 (0.84 - 1.4)	2.0 (1.4 - 2.6)	5.4^{E} (2.1 - 8.7)
Females, 40–59	2	605	5.79	0.82 (0.65 - 1.0)	0.18 (0.18 - 0.19)	0.85 (0.62 - 1.1)	1.7 (1.2 - 2.2)	4.7^{E} (2.1 - 7.3)
Females, 60–79	1	542	5.17	0.78 (0.57 - 1.1)	F	0.91 (0.74 - 1.1)	1.6 (1.1 - 2.1)	4.4 (3.0 - 5.8)
Females, 60–79	2	575	5.57	1.1 (0.84 - 1.5)	0.19^{E} (<LOD - 0.32)	1.2 (0.84 - 1.5)	2.2 (1.7 - 2.8)	F

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

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8.11 MOLYBDENUM

Molybdenum (CASRN 7439-98-7) is a naturally occurring element found throughout the Earth's crust at an average concentration of approximately 0.00015% (Emsley, 2001). It commonly exists in combination with other elements and does not occur as a free metal in nature. Molybdenum is an essential trace element required for the maintenance of good health in humans (IOM, 2001).

Molybdenum is found naturally in soil, sediment, surface water, groundwater, plants, animals, and humans. It may be released to the environment through natural processes such as the weathering of soil or ores from igneous and sedimentary rock (CCME, 1999). Anthropogenic sources include combustion of coal, municipal sewage sludge, and industrial and mining operations (CCME, 1999). The use of fertilizers is also an important anthropogenic source of molybdenum to aquatic systems.

The primary use of molybdenum is in the steel industry as a component of steel alloys to increase strength, durability, resistance to corrosion (Steifel, 2010). Other uses include electrical contacts, spark plugs, X-ray tubes, filaments, screens, grids for radio valves, glass-to-metal seals, nonferrous alloys, and pigments (WHO, 2011). It is also used in pigments for ceramics, inks, and paints (CDC, 2009). Molybdenum compounds are used in agriculture for the treatment of seeds and in the formulation of fertilizers to prevent molybdenum deficiency in crops (WHO, 2011).

Ingestion of food, and to a lesser degree drinking water, is the main route of exposure for the general population (WHO, 2011). Intake of molybdenum via air is considered an insignificant exposure source (WHO, 2011).

Absorption of dietary molybdenum from the gastrointestinal tract depends on the chemical form and ranges from 30% to 70% (WHO, 2011). Following gastrointestinal absorption, molybdenum rapidly appears in the blood and most organs with the highest concentrations found in the liver, kidney, and bone (WHO, 2011). However, there is no apparent bioaccumulation of molybdenum in human tissues (WHO, 2011). Molybdenum is primarily excreted in the urine, and urinary levels are a direct reflection of the dietary molybdenum intake level (IOM, 2001; Turnlund et al., 1995).

As an essential trace element, molybdenum is required as a cofactor for several enzymes and to aid in metabolizing proteins (EPA, 1993; WHO, 2011). Molybdenum deficiency is normally observed only in people with metabolic defects (IOM, 2001). On account of its essentiality, Health Canada has established recommended dietary allowances for molybdenum (Health Canada, 2010; IOM, 2001).

Toxicity data for molybdenum in humans are limited, and the adverse effects observed in laboratory animals are either not relevant for humans or have not been observed in humans (IOM, 2001). However, chronic exposure to high levels of molybdenum has been associated with gout-like symptoms in humans, including high uric acid concentrations and joint pain (EPA, 1993). Neither the International Agency for Research on Cancer nor Health Canada has published an evaluation of the carcinogenicity of molybdenum (ITER, 2010).

Tolerable upper intake levels for molybdenum, which account for its potential toxicity, have been developed by the Institute of Medicine and adopted by Health Canada (Health Canada, 2010a; IOM, 2001). Because molybdenum generally occurs at very low concentrations in drinking water, the World Health Organization considers it unnecessary to set a formal guideline value, but has provided a health-based value for guidance purposes (WHO, 2011). Currently, Health Canada has not set a guideline for molybdenum in drinking water (Health Canada, 2012).

In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric means for molybdenum in whole blood and in urine were 1.14 µg/L and 44.25 µg/L, respectively (INSPQ, 2004). In a study carried out in British Columbia to assess the levels of trace elements in 61 non-smoking adults aged 30 to 65 years, the geometric mean concentration for molybdenum in blood was 1.47 µg/L (Clark et al., 2007). In urine, the geometric mean and 95th percentile molybdenum values were 49.5 µg/g creatinine and 159.8 µg/g creatinine, respectively (Clark et al., 2007).

Molybdenum was measured in the whole blood and urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented in blood as µg/L (Tables 8.11.1, 8.11.2, and 8.11.3) and in urine as both µg/L (Tables 8.11.4, 8.11.5, and 8.11.6) and µg/g creatinine (Tables 8.11.7, 8.11.8, and 8.11.9). Finding a measurable amount of molybdenum in blood or urine is an indicator of exposure to molybdenum and does not necessarily mean that an adverse health effect will occur. Because molybdenum is an essential trace element required for the maintenance of health, its presence in biological fluids is expected.

Table 8.11.1

Molybdenum — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5319	0.09	0.67 (0.66 - 0.69)	0.40 (0.38 - 0.42)	0.66 (0.64 - 0.68)	0.86 (0.82 - 0.89)	1.3 (1.3 - 1.4)
Total, 6–79	2	5575	0.18	0.65 (0.63 - 0.67)	0.38 (0.36 - 0.39)	0.64 (0.62 - 0.66)	0.85 (0.82 - 0.88)	1.4 (1.3 - 1.5)
Males, Total 6–79	1	2576	0.12	0.67 (0.65 - 0.68)	0.40 (0.39 - 0.41)	0.65 (0.63 - 0.66)	0.85 (0.81 - 0.88)	1.3 (1.2 - 1.4)
Males, Total 6–79	2	2687	0.22	0.63 (0.61 - 0.66)	0.37 (0.34 - 0.40)	0.62 (0.59 - 0.65)	0.83 (0.80 - 0.87)	1.4 (1.3 - 1.5)
Females, Total 6–79	1	2743	0.07	0.68 (0.66 - 0.71)	0.40 (0.36 - 0.43)	0.67 (0.64 - 0.69)	0.87 (0.83 - 0.92)	1.4 (1.3 - 1.5)
Females, Total 6–79	2	2888	0.14	0.67 (0.64 - 0.70)	0.39 (0.37 - 0.41)	0.64 (0.61 - 0.67)	0.86 (0.83 - 0.89)	1.5 (1.4 - 1.5)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.11.2

Molybdenum — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6070	0.16	0.66 (0.64 - 0.68)	0.38 (0.36 - 0.40)	0.64 (0.62 - 0.66)	0.86 (0.84 - 0.89)	1.5 (1.4 - 1.5)
3–5[b]	1							
3–5	2	495	0	1.0 (0.96 - 1.1)	0.61 (0.52 - 0.70)	0.95 (0.91 - 0.98)	1.2 (1.1 - 1.3)	2.7[E] (1.4 - 4.0)
6–11	1	910	0	0.85 (0.83 - 0.87)	0.56 (0.54 - 0.58)	0.80 (0.75 - 0.84)	1.0 (0.96 - 1.0)	1.6 (1.5 - 1.7)
6–11	2	961	0.21	0.82 (0.77 - 0.87)	0.51 (0.49 - 0.54)	0.79 (0.75 - 0.84)	0.98 (0.92 - 1.0)	1.6 (1.2 - 2.1)
12–19	1	945	0.11	0.68 (0.63 - 0.72)	0.41 (0.38 - 0.44)	0.65 (0.60 - 0.70)	0.85 (0.79 - 0.91)	1.3 (1.1 - 1.5)
12–19	2	997	0	0.67 (0.65 - 0.71)	0.44 (0.41 - 0.47)	0.64 (0.62 - 0.67)	0.84 (0.79 - 0.90)	1.2 (1.1 - 1.3)
20–39	1	1165	0.09	0.65 (0.63 - 0.68)	0.40 (0.37 - 0.43)	0.63 (0.60 - 0.67)	0.82 (0.77 - 0.87)	1.3 (1.2 - 1.5)
20–39	2	1313	0.15	0.64 (0.61 - 0.67)	0.37 (0.30 - 0.44)	0.64 (0.62 - 0.66)	0.84 (0.79 - 0.89)	1.4 (1.2 - 1.6)
40–59	1	1220	0.08	0.64 (0.60 - 0.67)	0.37 (0.33 - 0.41)	0.63 (0.60 - 0.67)	0.81 (0.75 - 0.87)	1.2 (1.2 - 1.3)
40–59	2	1222	0.41	0.60 (0.57 - 0.63)	0.37 (0.33 - 0.40)	0.59 (0.56 - 0.61)	0.79 (0.76 - 0.82)	1.4 (1.2 - 1.5)
60–79	1	1079	0.19	0.73 (0.71 - 0.75)	0.41 (0.37 - 0.45)	0.72 (0.69 - 0.74)	0.93 (0.90 - 0.97)	1.6 (1.4 - 1.8)
60–79	2	1082	0.09	0.70 (0.66 - 0.75)	0.38 (0.36 - 0.41)	0.67 (0.62 - 0.72)	0.95 (0.89 - 1.0)	1.5 (1.4 - 1.7)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.11.3

Molybdenum — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2940	0.20	0.64 (0.62 - 0.66)	0.37 (0.35 - 0.40)	0.63 (0.60 - 0.66)	0.85 (0.81 - 0.89)	1.4 (1.3 - 1.5)
Males, 6–11	1	459	0	0.87 (0.84 - 0.91)	0.56 (0.52 - 0.61)	0.81 (0.74 - 0.89)	1.0 (0.96 - 1.1)	1.5 (1.5 - 1.6)
Males, 6–11	2	488	0.20	0.86 (0.78 - 0.95)	0.55 (0.49 - 0.60)	0.86 (0.78 - 0.94)	1.0 (0.92 - 1.1)	1.9[E] (1.2 - 2.7)
Males, 12–19	1	489	0	0.70 (0.65 - 0.74)	0.43 (0.39 - 0.48)	0.67 (0.62 - 0.71)	0.87 (0.81 - 0.92)	1.3 (0.92 - 1.7)
Males, 12–19	2	523	0	0.67 (0.64 - 0.70)	0.45 (0.39 - 0.50)	0.65 (0.60 - 0.70)	0.85 (0.79 - 0.91)	1.2 (1.0 - 1.4)
Males, 20–39	1	514	0	0.64 (0.61 - 0.67)	0.40 (0.36 - 0.45)	0.63 (0.59 - 0.66)	0.80 (0.75 - 0.85)	1.3 (1.1 - 1.5)
Males, 20–39	2	552	0.36	0.62 (0.58 - 0.66)	0.35 (0.27 - 0.43)	0.63 (0.58 - 0.68)	0.80 (0.71 - 0.90)	1.4 (1.0 - 1.7)
Males, 40–59	1	577	0.17	0.63 (0.60 - 0.67)	0.38 (0.32 - 0.43)	0.63 (0.59 - 0.67)	0.80 (0.73 - 0.86)	1.2 (1.1 - 1.3)
Males, 40–59	2	617	0.32	0.58 (0.55 - 0.62)	0.35 (0.27 - 0.43)	0.58 (0.54 - 0.62)	0.77 (0.72 - 0.82)	1.3 (0.99 - 1.5)
Males, 60–79	1	537	0.37	0.69 (0.65 - 0.74)	0.40 (0.36 - 0.44)	0.68 (0.64 - 0.72)	0.89 (0.85 - 0.94)	1.5 (1.3 - 1.7)
Males, 60–79	2	507	0.20	0.67 (0.61 - 0.73)	0.37 (0.33 - 0.42)	0.67 (0.60 - 0.73)	0.93 (0.85 - 1.0)	1.4 (1.3 - 1.5)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3130	0.13	0.68 (0.65 - 0.71)	0.39 (0.37 - 0.41)	0.65 (0.62 - 0.68)	0.88 (0.85 - 0.91)	1.5 (1.4 - 1.6)
Females, 6–11	1	451	0	0.83 (0.80 - 0.87)	0.56 (0.54 - 0.59)	0.77 (0.74 - 0.81)	1.0 (0.96 - 1.0)	1.6 (1.3 - 1.8)
Females, 6–11	2	473	0.21	0.78 (0.72 - 0.84)	0.50 (0.46 - 0.54)	0.75 (0.72 - 0.79)	0.95 (0.91 - 1.0)	1.4 (1.2 - 1.6)
Females, 12–19	1	456	0.22	0.65 (0.60 - 0.71)	0.39 (0.35 - 0.42)	0.63 (0.55 - 0.71)	0.83 (0.73 - 0.94)	1.3 (1.1 - 1.4)
Females, 12–19	2	474	0	0.68 (0.64 - 0.72)	0.43 (0.41 - 0.46)	0.64 (0.61 - 0.67)	0.83 (0.75 - 0.92)	1.2 (1.0 - 1.5)
Females, 20–39	1	651	0.15	0.67 (0.64 - 0.71)	0.40 (0.35 - 0.44)	0.64 (0.60 - 0.68)	0.85 (0.78 - 0.91)	1.4 (1.1 - 1.7)
Females, 20–39	2	761	0	0.66 (0.61 - 0.72)	0.38 (0.31 - 0.45)	0.64 (0.61 - 0.68)	0.85 (0.81 - 0.89)	1.5 (1.2 - 1.8)
Females, 40–59	1	643	0	0.64 (0.60 - 0.68)	0.37 (0.30 - 0.44)	0.63 (0.59 - 0.67)	0.82 (0.75 - 0.90)	1.2 (1.1 - 1.3)
Females, 40–59	2	605	0.50	0.62 (0.58 - 0.67)	0.38 (0.36 - 0.40)	0.60 (0.53 - 0.67)	0.80 (0.73 - 0.87)	1.4 (1.3 - 1.6)
Females, 60–79	1	542	0	0.77 (0.74 - 0.79)	0.44 (0.39 - 0.49)	0.74 (0.72 - 0.77)	0.99 (0.96 - 1.0)	1.6 (1.5 - 1.8)
Females, 60–79	2	575	0	0.73 (0.69 - 0.77)	0.39 (0.36 - 0.43)	0.70 (0.65 - 0.76)	0.96 (0.86 - 1.1)	1.6 (1.4 - 1.8)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.11.4

Molybdenum — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5492	0	36 (33 - 40)	9.9 (8.7 - 11)	40 (37 - 43)	70 (66 - 74)	130 (120 - 140)
Total, 6–79	2	5738	0.02	44 (41 - 47)	12 (10 - 14)	48 (45 - 51)	82 (76 - 88)	170 (150 - 190)
Males, Total 6–79	1	2662	0	42 (40 - 45)	12 (9.8 - 14)	47 (44 - 50)	76 (71 - 82)	150 (130 - 160)
Males, Total 6–79	2	2746	0.04	49 (45 - 52)	14 (11 - 17)	53 (49 - 56)	90 (82 - 98)	190 (160 - 210)
Females, Total 6–79	1	2830	0	31 (28 - 35)	8.6 (6.7 - 10)	34 (30 - 38)	63 (57 - 68)	120 (110 - 130)
Females, Total 6–79	2	2992	0	40 (37 - 43)	11 (9.5 - 12)	44 (39 - 48)	75 (67 - 84)	140 (110 - 170)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.11.5

Molybdenum — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6311	0.02	45 (42 - 48)	12 (11 - 14)	49 (46 - 52)	84 (78 - 89)	170 (150 - 190)
3–5[b]	1							
3–5	2	573	0	82 (75 - 90)	32 (27 - 36)	86 (77 - 95)	120 (120 - 130)	290 (200 - 380)
6–11	1	1034	0	57 (50 - 64)	19 (15 - 23)	60 (52 - 68)	100 (95 - 100)	170 (160 - 180)
6–11	2	1062	0	78 (72 - 85)	30 (27 - 34)	79 (70 - 88)	130 (110 - 140)	250 (190 - 320)
12–19	1	983	0	54 (47 - 62)	15 (11 - 19)	62 (55 - 70)	99 (92 - 110)	170 (150 - 190)
12–19	2	1041	0	65 (58 - 72)	20 (13 - 27)	69 (59 - 80)	100 (93 - 120)	190 (160 - 230)
20–39	1	1169	0	38 (33 - 43)	10 (7.2 - 13)	44 (39 - 49)	73 (67 - 79)	140 (110 - 160)
20–39	2	1321	0	49 (44 - 54)	14 (9.8 - 18)	53 (47 - 59)	87 (77 - 96)	190 (150 - 220)
40–59	1	1223	0	31 (28 - 33)	8.8 (7.1 - 10)	33 (31 - 36)	60 (56 - 64)	120 (100 - 130)
40–59	2	1228	0	38 (34 - 41)	9.6 (7.2 - 12)	41 (35 - 46)	73 (64 - 83)	120 (110 - 130)
60–79	1	1083	0	30 (28 - 33)	9.9 (8.8 - 11)	32 (29 - 35)	54 (51 - 58)	100 (95 - 110)
60–79	2	1086	0.09	32 (29 - 35)	9.4 (8.6 - 10)	35 (30 - 39)	57 (51 - 62)	110 (96 - 130)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.11.6

Molybdenum — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	0.03	50 (46 - 53)	15 (12 - 17)	53 (49 - 57)	92 (84 - 100)	190 (170 - 210)
Males, 6–11	1	524	0	59 (48 - 72)	20 (13 - 28)	64 (52 - 77)	100 (90 - 120)	180 (160 - 210)
Males, 6–11	2	532	0	89 (77 - 100)	39 (31 - 46)	90 (72 - 110)	140 (110 - 170)	280 (200 - 360)
Males, 12–19	1	505	0	57 (51 - 65)	20 (15 - 25)	64 (56 - 72)	96 (87 - 110)	180 (130 - 220)
Males, 12–19	2	542	0	72 (61 - 85)	28 (19 - 36)	81 (66 - 95)	110 (93 - 130)	200 (140 - 250)
Males, 20–39	1	514	0	42 (37 - 47)	11 (8.3 - 14)	48 (43 - 53)	78 (71 - 86)	160 (140 - 190)
Males, 20–39	2	551	0	52 (47 - 58)	13[E] (7.4 - 18)	59 (50 - 68)	98 (85 - 110)	200 (160 - 240)
Males, 40–59	1	578	0	38 (35 - 41)	10 (7.9 - 13)	42 (36 - 47)	69 (61 - 78)	130 (110 - 150)
Males, 40–59	2	616	0	41 (36 - 46)	13[E] (7.9 - 18)	43 (36 - 51)	76 (70 - 83)	120 (90 - 150)
Males, 60–79	1	541	0	36 (34 - 39)	13 (11 - 14)	37 (32 - 42)	61 (55 - 67)	110 (97 - 120)
Males, 60–79	2	505	0.20	36 (31 - 41)	11 (8.9 - 13)	40 (33 - 46)	59 (48 - 69)	120 (100 - 140)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	0	41 (38 - 44)	11 (9.7 - 12)	44 (40 - 48)	78 (69 - 86)	140 (120 - 170)
Females, 6–11	1	510	0	54 (47 - 62)	17 (13 - 22)	58 (49 - 67)	99 (87 - 110)	170 (140 - 190)
Females, 6–11	2	530	0	68 (62 - 75)	26 (20 - 31)	71 (62 - 80)	110 (91 - 130)	230 (180 - 280)
Females, 12–19	1	478	0	50 (40 - 63)	13[E] (7.5 - 18)	58 (48 - 69)	100 (89 - 110)	170 (140 - 190)
Females, 12–19	2	499	0	58 (52 - 64)	17 (12 - 23)	62 (56 - 69)	96 (89 - 100)	170 (140 - 200)
Females, 20–39	1	655	0	34 (28 - 41)	9.5 (6.0 - 13)	39 (31 - 46)	69 (59 - 79)	110 (89 - 130)
Females, 20–39	2	770	0	45 (39 - 53)	14 (9.4 - 19)	48 (37 - 60)	81 (68 - 95)	160[E] (85 - 240)
Females, 40–59	1	645	0	25 (22 - 28)	6.2 (4.0 - 8.4)	27 (24 - 31)	51 (45 - 56)	98 (90 - 110)
Females, 40–59	2	612	0	35 (30 - 39)	9.2 (7.2 - 11)	38 (30 - 46)	64 (53 - 74)	110 (100 - 130)
Females, 60–79	1	542	0	26 (22 - 30)	8.1 (6.0 - 10)	27 (21 - 32)	49 (45 - 52)	92 (77 - 110)
Females, 60–79	2	581	0	28 (26 - 31)	8.6 (7.6 - 9.6)	30 (26 - 34)	54 (46 - 62)	100 (84 - 120)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.11.7

Molybdenum (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5479	0	44 (42 - 46)	20 (19 - 22)	43 (42 - 44)	64 (61 - 67)	120 (110 - 130)
Total, 6–79	2	5719	0.02	41 (39 - 43)	19 (17 - 20)	41 (39 - 44)	61 (57 - 65)	120 (110 - 130)
Males, Total 6–79	1	2653	0	42 (40 - 43)	19 (18 - 21)	40 (39 - 42)	61 (57 - 65)	110 (100 - 120)
Males, Total 6–79	2	2739	0.04	39 (37 - 41)	18 (16 - 19)	38 (35 - 41)	58 (55 - 62)	120 (100 - 130)
Females, Total 6–79	1	2826	0	46 (44 - 49)	21 (19 - 23)	46 (43 - 48)	66 (62 - 70)	120 (110 - 130)
Females, Total 6–79	2	2980	0	44 (41 - 47)	20 (19 - 22)	43 (40 - 46)	64 (59 - 70)	120 (100 - 140)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.11.8

Molybdenum (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6291	0.02	43 (41 - 45)	19 (17 - 20)	42 (40 - 45)	64 (60 - 68)	140 (120 - 160)
3–5[b]	1							
3–5	2	572	0	140 (130 - 150)	59 (41 - 77)	140 (130 - 150)	190 (170 - 220)	490[E] (310 - 680)
6–11	1	1031	0	87 (84 - 91)	47 (43 - 50)	84 (79 - 89)	120 (110 - 120)	220 (190 - 240)
6–11	2	1058	0	88 (82 - 95)	42 (37 - 47)	85 (77 - 93)	130 (110 - 140)	260 (190 - 330)
12–19	1	982	0	47 (43 - 51)	21 (19 - 24)	46 (42 - 51)	69 (63 - 76)	110 (95 - 120)
12–19	2	1039	0	48 (45 - 51)	27 (25 - 28)	46 (41 - 50)	68 (61 - 74)	110 (85 - 140)
20–39	1	1165	0	42 (40 - 45)	20 (17 - 22)	42 (39 - 45)	59 (54 - 63)	110 (93 - 120)
20–39	2	1319	0	40 (37 - 42)	18 (16 - 20)	42 (39 - 45)	59 (52 - 65)	120 (85 - 160)
40–59	1	1218	0	39 (37 - 42)	19 (17 - 22)	39 (36 - 41)	55 (50 - 59)	100 (95 - 110)
40–59	2	1223	0	36 (34 - 39)	17 (15 - 19)	36 (33 - 38)	53 (49 - 56)	94 (78 - 110)
60–79	1	1083	0	43 (39 - 46)	19 (16 - 22)	43 (40 - 46)	61 (56 - 66)	110 (97 - 120)
60–79	2	1080	0.09	37 (34 - 40)	18 (15 - 21)	37 (33 - 41)	54 (49 - 59)	99 (90 - 110)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.11.9

Molybdenum (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	0.03	40 (39 - 42)	18 (16 - 19)	39 (36 - 43)	61 (57 - 66)	140 (120 - 150)
Males, 6–11	1	522	0	90 (84 - 96)	48 (41 - 54)	88 (81 - 94)	120 (110 - 130)	220 (200 - 250)
Males, 6–11	2	530	0	97 (86 - 110)	50 (39 - 61)	92 (79 - 100)	130 (120 - 150)	290 (190 - 380)
Males, 12–19	1	504	0	48 (44 - 53)	23 (20 - 25)	49 (44 - 53)	72 (65 - 79)	110 (85 - 130)
Males, 12–19	2	541	0	49 (44 - 54)	26 (22 - 31)	48 (42 - 55)	70 (60 - 80)	120[E] (57 - 180)
Males, 20–39	1	512	0	38 (36 - 41)	18 (16 - 19)	39 (36 - 42)	57 (50 - 63)	95 (76 - 110)
Males, 20–39	2	550	0	36 (34 - 39)	17 (15 - 18)	38 (33 - 44)	56 (50 - 62)	97 (66 - 130)
Males, 40–59	1	574	0	38 (35 - 40)	20 (18 - 22)	37 (35 - 38)	51 (47 - 55)	100 (86 - 120)
Males, 40–59	2	615	0	33 (30 - 36)	17 (14 - 19)	33 (30 - 36)	49 (44 - 54)	78 (62 - 93)
Males, 60–79	1	541	0	38 (35 - 42)	18 (15 - 21)	38 (34 - 42)	56 (50 - 61)	97 (88 - 110)
Males, 60–79	2	503	0.20	35 (32 - 38)	15 (13 - 18)	34 (29 - 39)	52 (45 - 60)	89 (80 - 98)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	0	46 (43 - 49)	21 (19 - 22)	44 (41 - 46)	67 (62 - 73)	150 (120 - 170)
Females, 6–11	1	509	0	85 (79 - 91)	46 (42 - 51)	81 (75 - 87)	110 (100 - 130)	200 (150 - 240)
Females, 6–11	2	528	0	80 (74 - 87)	38 (31 - 44)	79 (71 - 87)	120 (100 - 130)	220 (190 - 260)
Females, 12–19	1	478	0	45 (41 - 51)	20 (17 - 24)	44 (38 - 50)	67 (58 - 76)	110 (96 - 120)
Females, 12–19	2	498	0	48 (45 - 50)	27 (25 - 28)	45 (42 - 47)	67 (60 - 73)	110 (100 - 120)
Females, 20–39	1	653	0	46 (42 - 51)	24 (22 - 26)	45 (41 - 49)	62 (54 - 70)	120[E] (75 - 170)
Females, 20–39	2	769	0	44 (40 - 49)	21 (17 - 24)	43 (40 - 47)	65 (54 - 75)	120[E] (68 - 170)
Females, 40–59	1	644	0	41 (37 - 45)	19 (15 - 23)	41 (38 - 44)	60 (54 - 65)	100 (91 - 120)
Females, 40–59	2	608	0	40 (36 - 44)	18 (15 - 22)	40 (35 - 45)	58 (51 - 65)	110 (89 - 140)
Females, 60–79	1	542	0	47 (43 - 51)	20 (16 - 25)	48 (42 - 54)	69 (60 - 77)	120 (110 - 130)
Females, 60–79	2	577	0	40 (36 - 44)	20 (17 - 23)	39 (35 - 43)	56 (47 - 65)	110 (85 - 130)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

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8.12 NICKEL

Nickel (CASRN 7440-02-0) is a naturally occurring metal present in the Earth's crust at an average concentration of approximately 0.0075% (Environment Canada & Health Canada, 1994). In its pure form, nickel is hard and silvery white, and it occurs most frequently in combination with sulphur, arsenic, and antimony. Nickel is a very reactive base metal that forms various divalent compounds, including nickel sulphate, nickel oxide, nickel sulphide, nickel subsulphide, and nickel carbonate (Natural Resources Canada, 2012). Studies have suggested that nickel may be an essential trace element required to support biochemical processes in humans.

Nickel is found in many types of rock and released into the environment as a result of natural processes including the weathering of geological deposits (Environment Canada & Health Canada, 1994). Environmental releases of nickel also result from human activities such as fuel combustion, waste incineration, mining, smelting, refining, and other metal operations (Environment Canada & Health Canada, 1994).

Owing to its unique physical properties, nickel is commonly combined with other metals, including iron, copper, chromium, and zinc to form alloys (ATSDR, 2005). Nickel alloys are used in metal coins, jewellery, and heat exchangers. Nickel compounds are used in nickel plating, batteries, ceramic colouring, and as catalysts to increase rates of chemical reactions. Nickel is also a component of stainless steel that has widespread application in a variety of home, medical, and industrial settings (ATSDR, 2005; CCME, 1999).

The main source of nickel exposure for the general population is food (ATSDR, 2005). Drinking water is also a source of nickel exposure. Additional nickel exposure can occur through dermal contact with products such as jewellery, which often contain nickel alloys. Dermal contact can also occur through the use of nickel-containing products such as household cleaning and bleaching agents; cosmetics, where nickel is generally present as an impurity; and medical products including joint implants, intrauterine devices, and acupuncture needles (ATSDR, 2005; Basketter et al., 2003). Nickel exposure can also occur from inhalation of cigarette smoke (ATSDR, 2005). In the general non-smoking population, inhalation is a minor source of nickel intake (ATSDR, 2005).

Nickel and nickel compounds are absorbed from the respiratory tract and, to a lesser extent, from the gastrointestinal tract and skin (ATSDR, 2005; WHO, 1991). Approximately 20% to 35% of inhaled nickel is absorbed into the blood from the respiratory tract, whereas only 1% to 10% of ingested nickel is absorbed, depending largely on the composition of the diet (ATSDR, 2005; WHO, 1991). Nickel has been measured in a variety of organs including the lungs, thyroid, adrenals, kidneys, heart, liver, brain, spleen, and pancreas (ATSDR, 2005). Nickel is excreted in urine and feces, and has an estimated elimination half-life of 17 to 48 hours (Nieboer & Fletcher, 2001). Nickel can be measured in urine, serum, whole blood, feces, hair, sweat, and breast milk; urine is the most commonly used matrix for biological monitoring of nickel (Sunderman Jr., 1993).

Based on studies in laboratory animal species, nickel is proposed to be an essential element in humans (Environment Canada & Health Canada, 1994). However, there have been no studies to determine the nutritional importance of nickel in humans or to demonstrate its biochemical function (IOM, 2001). The Institute of Medicine has concluded that there is insufficient data to establish recommended dietary allowances or adequate intakes (Health Canada, 2010; IOM, 2001).

Although there may be benefits from small doses of nickel, exposure to high levels may result in adverse health effects. These effects depend on the route of exposure and, in the case of inhalation, the species of nickel. At high concentrations, acute oral exposure can cause gastrointestinal effects; chronic inhalation exposure has led to chronic bronchitis and reduced lung function in humans (ATSDR, 2005). Allergic reactions to nickel are the most common adverse effect and can lead to severe contact dermatitis. The condition can be painful but is not life threatening, and it can be managed by avoiding extended contact between the skin and nickel-containing jewellery, buttons, belt buckles, and similar items (ATSDR, 2005).

Health Canada has classified metallic nickel as Group VI, unclassifiable with respect to carcinogenicity in humans; however, oxidic, sulphidic and soluble nickel are classified as Group I, carcinogenic to humans, for inhalation exposure (Environment Canada & Health Canada, 1994). Similarly, the International Agency for Research on Cancer has classified nickel compounds as Group 1, carcinogenic to humans, and metallic and alloy nickel as Group 2B, possibly carcinogenic to humans (IARC, 1990; IARC, 2012)

Health Canada and Environment Canada assessed nickel and its various compounds, and concluded that metallic nickel was not a concern for human health at current levels of exposure (Environment Canada & Health Canada, 1994). However, the oxidic, sulphidic, and soluble nickel groups (primarily nickel sulphate and nickel chloride), as a whole, are entering the environment in a quantity or concentration or under conditions that may constitute a danger in Canada to human life or health. Oxidic, sulphidic, and soluble inorganic nickel compounds are listed on Schedule 1, List of Toxic Substances, under the *Canadian Environmental Protection Act, 1999* (CEPA 1999). The Act allows the federal government to control the importation, manufacture, distribution, and use of oxidic, sulphidic, and soluble inorganic nickel compounds in Canada (Canada, 1999; Canada, 2000). Risk management actions under CEPA 1999 have been developed to control releases of oxidic, sulphidic, and soluble inorganic nickel compounds from thermal electric power generation, base-metal smelting, and steel manufacturing processes (Environment Canada, 2010). Tolerable upper intake levels for nickel, which account for its potential toxicity, have been developed by the Institute of Medicine and adopted by Health Canada (Health Canada, 2010; IOM, 2001). Nickel is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply.

In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric means of nickel in whole blood and urine were <0.59 µg/L and 1.78 µg/L, respectively (INSPQ, 2004).

Nickel was measured in the whole blood and urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented in blood as µg/L (Tables 8.12.1, 8.12.2, and 8.12.3) and in urine as both µg/L (Tables 8.12.4, 8.12.5, and 8.12.6) and µg/g creatinine (Tables 8.12.7, 8.12.8, and 8.12.9). Finding a measurable amount of nickel in blood or urine is an indicator of exposure to nickel and does not necessarily mean that an adverse health effect will occur.

Table 8.12.1

Nickel — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5319	6.69	0.63 (0.57 - 0.70)	<LOD	0.53 (0.52 - 0.55)	0.60[E] (<LOD - 1.0)	1.6 (1.3 - 2.0)
Total, 6–79	2	5572	12.15	0.48 (0.45 - 0.51)	<LOD	0.49 (0.46 - 0.52)	0.56 (0.55 - 0.57)	1.1 (1.1 - 1.2)
Males, Total 6–79	1	2576	6.72	0.62 (0.56 - 0.69)	<LOD	0.53 (0.51 - 0.55)	0.59[E] (<LOD - 0.95)	1.5 (1.2 - 1.8)
Males, Total 6–79	2	2685	10.99	0.48 (0.45 - 0.51)	<LOD	0.50 (0.47 - 0.53)	0.56 (0.55 - 0.57)	1.1 (1.0 - 1.2)
Females, Total 6–79	1	2743	6.67	0.64 (0.58 - 0.71)	<LOD	0.54 (0.52 - 0.55)	F	1.8 (1.4 - 2.2)
Females, Total 6–79	2	2887	13.23	0.47 (0.44 - 0.50)	<LOD	0.48 (0.44 - 0.52)	0.56 (0.55 - 0.57)	1.1 (1.1 - 1.2)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.12.2

Nickel — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group, Canadian Health Measures Survey cycle 1 (2007-2009) and cycle 2 (2009-2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6067	11.95	0.48 (0.45 - 0.51)	<LOD	0.49 (0.46 - 0.52)	0.56 (0.55 - 0.57)	1.1 (1.1 - 1.2)
3–5[b]	1							
3–5	2	495	9.70	0.51 (0.46 - 0.56)	<LOD (<LOD - 0.33)	0.52 (0.47 - 0.57)	0.57 (0.55 - 0.58)	1.2 (0.96 - 1.4)
6–11	1	910	6.37	0.68 (0.61 - 0.77)	<LOD	0.54 (0.53 - 0.56)	1.0[E] (0.46 - 1.6)	2.1 (1.5 - 2.8)
6–11	2	961	12.80	0.46 (0.42 - 0.50)	<LOD	0.47 (0.41 - 0.53)	0.56 (0.54 - 0.57)	1.1 (0.97 - 1.3)
12–19	1	945	7.20	0.64 (0.56 - 0.74)	<LOD	0.54 (0.52 - 0.56)	0.92[E] (0.40 - 1.4)	1.8 (1.4 - 2.1)
12–19	2	996	13.65	0.46 (0.40 - 0.52)	<LOD	0.47 (0.40 - 0.54)	0.56 (0.54 - 0.57)	1.1 (0.75 - 1.5)
20–39	1	1165	6.95	0.62 (0.58 - 0.67)	<LOD	0.53 (0.52 - 0.55)	0.59[E] (<LOD - 0.83)	1.6 (1.1 - 2.0)
20–39	2	1313	12.49	0.45 (0.41 - 0.51)	<LOD	0.48 (0.44 - 0.52)	0.56 (0.54 - 0.57)	1.1[E] (0.71 - 1.6)
40–59	1	1220	6.80	0.61 (0.54 - 0.70)	<LOD	0.53 (0.51 - 0.55)	0.59[E] (<LOD - 0.94)	1.6 (1.2 - 2.0)
40–59	2	1222	11.37	0.50 (0.48 - 0.53)	<LOD[E] (<LOD - 0.32)	0.51 (0.49 - 0.53)	0.56 (0.56 - 0.57)	1.1 (1.1 - 1.2)
60–79	1	1079	6.12	0.65 (0.58 - 0.71)	<LOD	0.54 (0.52 - 0.56)	0.94[E] (<LOD - 1.5)	1.6 (1.0 - 2.1)
60–79	2	1080	10.65	0.48 (0.44 - 0.51)	<LOD	0.48 (0.45 - 0.52)	0.56 (0.55 - 0.57)	1.1 (1.1 - 1.2)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.12.3

Nickel — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2938	10.96	0.48 (0.45 - 0.51)	<LOD	0.50 (0.47 - 0.53)	0.56 (0.55 - 0.57)	1.1 (1.1 - 1.2)
Males, 6–11	1	459	8.06	0.67 (0.60 - 0.76)	<LOD	0.54 (0.52 - 0.56)	1.0[E] (0.41 - 1.6)	2.3 (1.6 - 3.0)
Males, 6–11	2	488	12.91	0.45 (0.41 - 0.50)	<LOD	0.45 (0.39 - 0.52)	0.55 (0.52 - 0.58)	1.1 (0.83 - 1.4)
Males, 12–19	1	489	7.98	0.64 (0.57 - 0.72)	<LOD	0.54 (0.52 - 0.56)	1.0[E] (0.45 - 1.6)	1.7 (1.4 - 2.1)
Males, 12–19	2	522	11.49	0.46 (0.41 - 0.53)	<LOD	0.49 (0.41 - 0.57)	0.56 (0.54 - 0.58)	1.1[E] (0.49 - 1.6)
Males, 20–39	1	514	5.84	0.60 (0.54 - 0.67)	<LOD	0.53 (0.51 - 0.55)	0.59 (0.46 - 0.72)	1.3 (1.1 - 1.5)
Males, 20–39	2	552	10.87	0.47 (0.43 - 0.52)	<LOD	0.49 (0.46 - 0.52)	0.56 (0.55 - 0.57)	1.1 (0.74 - 1.5)
Males, 40–59	1	577	6.93	0.60 (0.52 - 0.70)	<LOD	0.53 (0.50 - 0.55)	0.59[E] (<LOD - 0.96)	1.5 (1.1 - 1.9)
Males, 40–59	2	617	10.53	0.49 (0.46 - 0.53)	F	0.52 (0.49 - 0.55)	0.56 (0.56 - 0.57)	1.1 (0.84 - 1.4)
Males, 60–79	1	537	5.03	0.64 (0.59 - 0.71)	<LOD	0.54 (0.51 - 0.56)	0.91[E] (<LOD - 1.4)	1.7 (1.2 - 2.3)
Males, 60–79	2	506	9.29	0.49 (0.46 - 0.54)	<LOD[E] (<LOD - 0.32)	0.49 (0.45 - 0.53)	0.56 (0.55 - 0.57)	1.2 (1.1 - 1.2)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3129	12.88	0.47 (0.44 - 0.50)	<LOD	0.48 (0.45 - 0.52)	0.56 (0.55 - 0.57)	1.1 (1.1 - 1.2)
Females, 6–11	1	451	4.66	0.70 (0.61 - 0.80)	<LOD (<LOD - 0.40)	0.55 (0.52 - 0.57)	1.1[E] (0.60 - 1.6)	1.9[E] (1.2 - 2.6)
Females, 6–11	2	473	12.68	0.47 (0.43 - 0.51)	<LOD	0.49 (0.43 - 0.54)	0.56 (0.55 - 0.58)	1.1 (0.94 - 1.3)
Females, 12–19	1	456	6.36	0.65 (0.55 - 0.76)	<LOD	0.54 (0.51 - 0.56)	F	1.8 (1.2 - 2.3)
Females, 12–19	2	474	16.03	0.45 (0.38 - 0.52)	<LOD	0.45 (0.39 - 0.51)	0.55 (0.54 - 0.57)	1.1[E] (0.42 - 1.9)
Females, 20–39	1	651	7.83	0.65 (0.59 - 0.70)	<LOD	0.54 (0.52 - 0.55)	F	1.9 (1.5 - 2.4)
Females, 20–39	2	761	13.67	0.44 (0.39 - 0.50)	<LOD	0.46 (0.41 - 0.51)	0.55 (0.54 - 0.57)	1.1[E] (0.62 - 1.7)
Females, 40–59	1	643	6.69	0.62 (0.55 - 0.71)	<LOD	0.53 (0.51 - 0.55)	0.60[E] (<LOD - 0.94)	1.8 (1.3 - 2.3)
Females, 40–59	2	605	12.23	0.51 (0.48 - 0.55)	<LOD (<LOD - 0.34)	0.50 (0.48 - 0.53)	0.56 (0.52 - 0.61)	1.2 (0.96 - 1.3)
Females, 60–79	1	542	7.20	0.65 (0.57 - 0.74)	<LOD	0.54 (0.52 - 0.56)	0.95[E] (<LOD - 1.5)	1.6 (1.0 - 2.1)
Females, 60–79	2	574	11.85	0.46 (0.41 - 0.51)	<LOD	0.48 (0.43 - 0.53)	0.56 (0.55 - 0.57)	1.1 (0.90 - 1.2)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.12.4

Nickel — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5491	3.15	1.1 (1.0 - 1.2)	0.29[E] (<LOD - 0.43)	1.1 (1.0 - 1.2)	2.0 (1.9 - 2.1)	4.4 (4.0 - 4.8)
Total, 6–79	2	5737	4.29	1.3 (1.3 - 1.4)	0.45 (0.40 - 0.50)	1.4 (1.3 - 1.5)	2.3 (2.1 - 2.4)	4.8 (4.2 - 5.4)
Males, Total 6–79	1	2662	2.85	1.1 (1.1 - 1.2)	0.40 (0.36 - 0.43)	1.1 (1.1 - 1.2)	2.0 (1.8 - 2.2)	4.5 (3.8 - 5.3)
Males, Total 6–79	2	2745	3.53	1.4 (1.3 - 1.5)	0.50 (0.42 - 0.57)	1.4 (1.3 - 1.5)	2.3 (2.1 - 2.6)	4.7 (4.0 - 5.5)
Females, Total 6–79	1	2829	3.43	1.1 (0.97 - 1.2)	0.27 (<LOD - 0.36)	1.1 (0.96 - 1.2)	2.0 (1.8 - 2.1)	4.3 (3.6 - 5.0)
Females, Total 6–79	2	2992	4.98	1.3 (1.2 - 1.4)	0.43 (0.38 - 0.47)	1.4 (1.3 - 1.5)	2.2 (2.0 - 2.4)	4.8 (3.8 - 5.8)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.12.5

Nickel — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6310	4.29	1.3 (1.3 - 1.4)	0.45 (0.40 - 0.50)	1.4 (1.3 - 1.5)	2.3 (2.1 - 2.4)	4.8 (4.2 - 5.3)
3–5[b]	1							
3–5	2	573	4.36	1.4 (1.3 - 1.6)	0.58 (0.45 - 0.72)	1.4 (1.2 - 1.6)	2.3 (2.0 - 2.6)	4.5 (3.4 - 5.6)
6–11	1	1034	2.80	1.3 (1.1 - 1.6)	0.40[E] (0.23 - 0.57)	1.4 (1.2 - 1.6)	2.5 (2.2 - 2.9)	5.0 (4.2 - 5.8)
6–11	2	1061	2.45	1.7 (1.6 - 1.8)	0.59 (0.53 - 0.64)	1.7 (1.5 - 1.9)	2.8 (2.5 - 3.2)	5.8 (5.1 - 6.4)
12–19	1	983	1.73	1.5 (1.4 - 1.7)	0.48 (0.37 - 0.59)	1.6 (1.5 - 1.7)	2.5 (2.3 - 2.8)	5.3 (4.2 - 6.4)
12–19	2	1041	3.07	1.6 (1.5 - 1.8)	0.56 (0.46 - 0.67)	1.7 (1.5 - 1.8)	2.7 (2.5 - 3.0)	4.7 (4.1 - 5.3)
20–39	1	1168	3.68	1.0 (0.89 - 1.1)	0.26 (<LOD - 0.34)	1.0 (0.92 - 1.1)	1.7 (1.5 - 2.0)	3.7 (3.1 - 4.3)
20–39	2	1321	5.22	1.3 (1.2 - 1.4)	0.45 (0.36 - 0.54)	1.3 (1.2 - 1.5)	2.1 (1.9 - 2.3)	5.0 (3.8 - 6.2)
40–59	1	1223	5.07	1.0 (0.96 - 1.1)	0.27 (<LOD - 0.35)	1.0 (0.93 - 1.1)	2.0 (1.8 - 2.1)	4.6 (3.3 - 5.9)
40–59	2	1228	5.78	1.3 (1.1 - 1.4)	0.42 (0.31 - 0.53)	1.3 (1.2 - 1.4)	2.1 (1.9 - 2.4)	4.3 (3.2 - 5.4)
60–79	1	1083	2.03	1.1 (1.1 - 1.2)	0.40 (0.32 - 0.48)	1.1 (1.0 - 1.2)	1.9 (1.8 - 2.1)	4.7 (3.8 - 5.5)
60–79	2	1086	4.42	1.3 (1.2 - 1.4)	0.43 (0.33 - 0.53)	1.3 (1.2 - 1.4)	2.2 (1.9 - 2.4)	4.7 (4.1 - 5.3)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.12.6

Nickel — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3035	3.66	1.4 (1.3 - 1.5)	0.50 (0.42 - 0.57)	1.4 (1.3 - 1.5)	2.3 (2.1 - 2.6)	4.7 (4.1 - 5.4)
Males, 6–11	1	524	3.05	1.3 (1.0 - 1.7)	F	1.4 (1.1 - 1.8)	2.6 (2.1 - 3.1)	4.6 (4.0 - 5.2)
Males, 6–11	2	531	1.69	1.9 (1.6 - 2.2)	0.66 (0.50 - 0.82)	1.9 (1.5 - 2.2)	3.0 (2.3 - 3.7)	5.9 (4.2 - 7.7)
Males, 12–19	1	505	1.19	1.4 (1.3 - 1.6)	0.47 (0.37 - 0.57)	1.5 (1.3 - 1.6)	2.2 (2.0 - 2.5)	4.8 (3.1 - 6.5)
Males, 12–19	2	542	2.40	1.6 (1.4 - 1.8)	0.59 (0.43 - 0.74)	1.7 (1.5 - 1.9)	2.6 (2.2 - 2.9)	4.6 (3.7 - 5.4)
Males, 20–39	1	514	3.89	1.0 (0.90 - 1.1)	0.26[E] (<LOD - 0.40)	1.0 (0.97 - 1.1)	1.6 (1.3 - 1.9)	3.7 (3.0 - 4.5)
Males, 20–39	2	551	5.81	1.3 (1.2 - 1.4)	0.46 (0.31 - 0.62)	1.4 (1.1 - 1.6)	2.2 (1.8 - 2.6)	4.5 (3.2 - 5.7)
Males, 40–59	1	578	4.33	1.1 (0.99 - 1.3)	0.39 (0.27 - 0.52)	1.1 (0.91 - 1.3)	2.0 (1.7 - 2.3)	5.4 (4.5 - 6.4)
Males, 40–59	2	616	4.22	1.3 (1.2 - 1.4)	0.45 (0.32 - 0.58)	1.3 (1.2 - 1.5)	2.1 (1.7 - 2.6)	4.1 (3.2 - 5.0)
Males, 60–79	1	541	1.66	1.3 (1.1 - 1.4)	0.47 (0.43 - 0.50)	1.2 (1.1 - 1.4)	2.1 (1.7 - 2.5)	5.5 (3.5 - 7.5)
Males, 60–79	2	505	3.37	1.3 (1.2 - 1.5)	0.49 (0.36 - 0.61)	1.3 (1.2 - 1.4)	2.2 (1.8 - 2.6)	5.4 (3.8 - 7.0)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	4.89	1.3 (1.2 - 1.4)	0.43 (0.39 - 0.47)	1.4 (1.3 - 1.5)	2.2 (2.0 - 2.4)	4.8 (3.9 - 5.7)
Females, 6–11	1	510	2.55	1.3 (1.2 - 1.5)	0.43 (0.29 - 0.58)	1.3 (1.1 - 1.5)	2.3 (2.0 - 2.7)	5.5 (4.5 - 6.5)
Females, 6–11	2	530	3.21	1.5 (1.4 - 1.7)	0.55 (0.44 - 0.65)	1.6 (1.4 - 1.7)	2.6 (2.1 - 3.0)	5.3 (4.6 - 6.1)
Females, 12–19	1	478	2.30	1.6 (1.4 - 1.9)	0.49[E] (<LOD - 0.78)	1.8 (1.6 - 2.0)	3.0 (2.6 - 3.3)	5.7 (4.0 - 7.5)
Females, 12–19	2	499	3.81	1.6 (1.4 - 1.8)	0.48 (0.35 - 0.60)	1.7 (1.5 - 1.9)	3.0 (2.7 - 3.3)	5.0 (4.5 - 5.5)
Females, 20–39	1	654	3.52	1.0 (0.82 - 1.2)	0.26[E] (<LOD - 0.40)	1.0 (0.81 - 1.2)	1.8 (1.4 - 2.2)	3.3 (2.2 - 4.4)
Females, 20–39	2	770	4.81	1.3 (1.2 - 1.5)	0.45 (0.34 - 0.55)	1.3 (1.2 - 1.5)	2.0 (1.8 - 2.3)	5.3[E] (2.8 - 7.8)
Females, 40–59	1	645	5.74	0.96 (0.85 - 1.1)	0.23 (<LOD - 0.31)	1.0 (0.85 - 1.1)	1.9 (1.7 - 2.1)	3.8[E] (2.2 - 5.5)
Females, 40–59	2	612	7.35	1.2 (1.1 - 1.4)	0.33[E] (<LOD - 0.50)	1.3 (1.2 - 1.5)	2.1 (1.8 - 2.4)	4.4[E] (2.3 - 6.5)
Females, 60–79	1	542	2.40	1.0 (0.93 - 1.1)	0.30[E] (<LOD - 0.43)	1.0 (0.89 - 1.1)	1.7 (1.5 - 1.9)	4.3 (3.3 - 5.3)
Females, 60–79	2	581	5.34	1.2 (1.1 - 1.4)	0.39 (<LOD - 0.49)	1.4 (1.2 - 1.6)	2.1 (1.8 - 2.4)	4.3 (3.5 - 5.1)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.12.7

Nickel (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5478	3.16	1.3 (1.3 - 1.4)	0.55 (<LOD - 0.58)	1.3 (1.2 - 1.3)	2.0 (1.9 - 2.1)	4.5 (3.9 - 5.0)
Total, 6–79	2	5718	4.30	1.2 (1.2 - 1.3)	0.56 (0.51 - 0.61)	1.2 (1.1 - 1.3)	1.9 (1.8 - 2.0)	4.0 (3.5 - 4.4)
Males, Total 6–79	1	2653	2.86	1.1 (1.1 - 1.2)	0.48 (0.45 - 0.52)	1.1 (0.99 - 1.1)	1.7 (1.6 - 1.8)	3.7 (3.2 - 4.3)
Males, Total 6–79	2	2738	3.54	1.1 (1.0 - 1.1)	0.49 (0.45 - 0.53)	1.0 (0.97 - 1.1)	1.6 (1.5 - 1.6)	3.2 (2.6 - 3.7)
Females, Total 6–79	1	2825	3.43	1.6 (1.5 - 1.7)	0.70 (<LOD - 0.76)	1.5 (1.4 - 1.6)	2.3 (2.1 - 2.5)	5.2 (4.3 - 6.1)
Females, Total 6–79	2	2980	5.00	1.4 (1.3 - 1.5)	0.67 (0.58 - 0.75)	1.4 (1.3 - 1.4)	2.2 (1.9 - 2.4)	4.6 (4.0 - 5.1)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.12.8

Nickel (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6290	4.31	1.3 (1.2 - 1.3)	0.57 (0.52 - 0.61)	1.2 (1.2 - 1.3)	1.9 (1.8 - 2.0)	4.2 (3.8 - 4.6)
3–5[b]	1							
3–5	2	572	4.37	2.4 (2.1 - 2.7)	1.0 (0.75 - 1.3)	2.4 (2.0 - 2.8)	3.5 (3.2 - 3.9)	6.1 (5.0 - 7.2)
6–11	1	1031	2.81	2.0 (1.8 - 2.3)	0.85 (0.69 - 1.0)	2.0 (1.7 - 2.2)	3.0 (2.7 - 3.3)	5.6 (4.6 - 6.7)
6–11	2	1057	2.46	1.9 (1.8 - 2.0)	0.93 (0.86 - 1.0)	1.9 (1.8 - 2.1)	2.7 (2.5 - 2.9)	5.7 (4.7 - 6.7)
12–19	1	982	1.73	1.3 (1.2 - 1.4)	0.57 (0.52 - 0.63)	1.3 (1.1 - 1.4)	2.0 (1.7 - 2.3)	3.9 (3.6 - 4.3)
12–19	2	1039	3.08	1.2 (1.1 - 1.3)	0.58 (0.51 - 0.64)	1.1 (1.1 - 1.2)	1.8 (1.6 - 2.0)	3.0 (2.7 - 3.3)
20–39	1	1164	3.69	1.1 (1.0 - 1.2)	0.46 (<LOD - 0.51)	1.1 (0.96 - 1.2)	1.6 (1.5 - 1.8)	3.9 (2.9 - 4.8)
20–39	2	1319	5.23	1.1 (1.0 - 1.1)	0.49 (0.44 - 0.54)	1.0 (0.94 - 1.1)	1.5 (1.3 - 1.7)	3.5 (3.0 - 3.9)
40–59	1	1218	5.09	1.3 (1.3 - 1.4)	0.57 (<LOD - 0.61)	1.3 (1.2 - 1.4)	2.0 (1.9 - 2.1)	4.4 (3.5 - 5.4)
40–59	2	1223	5.81	1.2 (1.1 - 1.3)	0.54 (0.47 - 0.62)	1.2 (1.1 - 1.3)	1.7 (1.5 - 1.9)	3.7 (2.9 - 4.6)
60–79	1	1083	2.03	1.6 (1.5 - 1.7)	0.67 (0.59 - 0.75)	1.5 (1.4 - 1.6)	2.4 (2.3 - 2.5)	5.3 (4.8 - 5.8)
60–79	2	1080	4.44	1.5 (1.4 - 1.6)	0.65 (0.57 - 0.73)	1.4 (1.3 - 1.5)	2.3 (2.1 - 2.5)	4.9 (4.4 - 5.3)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.12.9

Nickel (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3027	3.67	1.1 (1.0 - 1.2)	0.49 (0.45 - 0.53)	1.1 (1.0 - 1.1)	1.6 (1.5 - 1.7)	3.4 (2.9 - 4.0)
Males, 6–11	1	522	3.07	2.0 (1.7 - 2.3)	0.83 (<LOD - 1.0)	2.0 (1.7 - 2.4)	2.9 (2.6 - 3.1)	5.2 (3.5 - 7.0)
Males, 6–11	2	529	1.70	2.1 (1.8 - 2.3)	1.0 (0.86 - 1.1)	2.1 (1.8 - 2.3)	2.7 (2.4 - 3.1)	6.5 (4.7 - 8.3)
Males, 12–19	1	504	1.19	1.2 (1.1 - 1.3)	0.55 (0.47 - 0.63)	1.0 (0.92 - 1.2)	1.8 (1.6 - 2.0)	4.1 (3.4 - 4.9)
Males, 12–19	2	541	2.40	1.1 (1.0 - 1.2)	0.52 (0.42 - 0.62)	1.0 (0.96 - 1.1)	1.5 (1.3 - 1.7)	2.8 (2.4 - 3.2)
Males, 20–39	1	512	3.91	0.92 (0.81 - 1.1)	0.40 (<LOD - 0.45)	0.90 (0.78 - 1.0)	1.4 (1.1 - 1.7)	2.8 (2.0 - 3.6)
Males, 20–39	2	550	5.82	0.88 (0.80 - 0.97)	0.44 (0.36 - 0.51)	0.89 (0.79 - 0.99)	1.2 (1.1 - 1.4)	2.3 (1.6 - 3.0)
Males, 40–59	1	574	4.36	1.1 (1.0 - 1.2)	0.50 (0.43 - 0.56)	1.0 (0.94 - 1.1)	1.6 (1.4 - 1.8)	3.4 (2.5 - 4.3)
Males, 40–59	2	615	4.23	1.0 (0.93 - 1.1)	0.47 (0.40 - 0.54)	1.0 (0.88 - 1.1)	1.5 (1.3 - 1.6)	3.1 (2.0 - 4.2)
Males, 60–79	1	541	1.66	1.3 (1.2 - 1.4)	0.57 (0.49 - 0.64)	1.2 (1.1 - 1.3)	2.0 (1.7 - 2.3)	4.7 (3.2 - 6.3)
Males, 60–79	2	503	3.38	1.3 (1.2 - 1.4)	0.59 (0.56 - 0.63)	1.2 (1.1 - 1.3)	1.9 (1.7 - 2.1)	3.6[E] (2.2 - 4.9)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	4.90	1.5 (1.3 - 1.6)	0.67 (0.59 - 0.75)	1.4 (1.3 - 1.5)	2.2 (2.0 - 2.5)	4.6 (4.0 - 5.1)
Females, 6–11	1	509	2.55	2.1 (1.8 - 2.3)	0.93 (0.78 - 1.1)	1.9 (1.7 - 2.1)	3.1 (2.6 - 3.6)	5.7 (4.5 - 6.9)
Females, 6–11	2	528	3.22	1.8 (1.6 - 1.9)	0.85 (0.69 - 1.0)	1.9 (1.7 - 2.1)	2.7 (2.4 - 3.0)	4.8 (3.8 - 5.8)
Females, 12–19	1	478	2.30	1.5 (1.3 - 1.7)	0.63 (<LOD - 0.80)	1.5 (1.3 - 1.6)	2.2 (1.8 - 2.6)	3.9 (3.3 - 4.5)
Females, 12–19	2	498	3.82	1.3 (1.2 - 1.4)	0.64 (0.55 - 0.72)	1.3 (1.2 - 1.4)	2.0 (1.8 - 2.2)	3.6 (2.9 - 4.2)
Females, 20–39	1	652	3.53	1.4 (1.2 - 1.6)	0.63 (<LOD - 0.73)	1.3 (1.1 - 1.4)	2.0 (1.8 - 2.2)	4.6 (3.7 - 5.5)
Females, 20–39	2	769	4.81	1.3 (1.1 - 1.5)	0.61 (0.52 - 0.70)	1.2 (1.1 - 1.3)	1.9 (1.4 - 2.3)	3.9 (3.0 - 4.8)
Females, 40–59	1	644	5.75	1.6 (1.5 - 1.7)	0.73 (<LOD - 0.80)	1.5 (1.4 - 1.6)	2.3 (2.0 - 2.5)	4.9 (3.6 - 6.3)
Females, 40–59	2	608	7.40	1.4 (1.2 - 1.6)	0.66 (<LOD - 0.74)	1.4 (1.2 - 1.5)	2.0 (1.7 - 2.4)	4.5[E] (2.8 - 6.2)
Females, 60–79	1	542	2.40	1.9 (1.7 - 2.0)	0.81 (<LOD - 0.96)	1.8 (1.7 - 2.0)	2.7 (2.3 - 3.0)	5.9 (4.8 - 7.0)
Females, 60–79	2	577	5.37	1.7 (1.5 - 1.9)	0.76 (<LOD - 0.91)	1.6 (1.4 - 1.8)	2.8 (2.4 - 3.1)	5.2 (4.2 - 6.2)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

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8.13 SELENIUM

Selenium (CASRN 7782-49-2) is a naturally occurring trace mineral distributed widely in the environment and present in the Earth's crust at concentrations averaging 0.000009% (Schamberger, 1984). Selenium is present in the environment in the inorganic form as selenide, selenate, and selenite but rarely as elemental selenium. Selenium is an essential trace element required for the maintenance of good health in humans.

Selenium in its organic form is found in trace quantities in most plants and animal tissues (Schamberger, 1984). Elevated levels of selenium in the environment may occur naturally from weathering of base-metal deposits and soils (CCME, 2009). Selenium is also released to the environment as a result of anthropogenic activities such as mining or metallurgical processes (CCME, 2009). Other sources of anthropogenic selenium emissions include incinerator stacks, burning coal and oil, and large-scale combustion processes.

Historically, the primary use of selenium was in the electronics industry in the form of arsenic triselenide, used as a photoreceptor for photocopiers (USGS, 2001). Because selenium has various electrical and conductive properties, it is also used in light meters, photoelectric and solar cells, semiconductors, and arc-light electrodes. It is also used as a colourizing and decolourizing agent for glass, and to reduce solar heat for architectural glass (USGS, 2004). Selenium is also present in stainless steel, enamels, inks, rubber, batteries, explosives, fertilizers, animal feed, pharmaceuticals, and shampoos (ATSDR, 2003).

The Canadian population is exposed to selenium compounds in food, ambient air, drinking water, soil, and natural health products. More than 99% of the total daily intake of selenium is estimated to occur through the diet (CCME, 2009). Absorption of selenium depends on the chemical form; organic forms are absorbed more readily (>90%) than inorganic forms (>50%) (IOM, 2000). Absorption also depends on the overall exposure level; absorption increases when selenium levels in the body are low (IOM, 2000). Once inside the body, selenium generally concentrates in the liver and kidneys regardless of the initial chemical form. It can also be found in nails and hair (IOM, 2000). Selenium elimination is triphasic with biological half-lives of approximately 1 day, 1 week, and 3 months (ATSDR, 2003). Approximately 50% to 80% of absorbed selenium is eliminated in the urine (Marier & Jaworski, 1983). Selenium levels in the body following both short- and long-term exposure can be determined through blood and urine tests (IOM, 2000). Human breath can also be used as a biomarker for selenium exposure when large amounts of selenium are being excreted (IOM, 2000).

As an essential trace element, selenium is required as a component of several proteins and enzymes in the body (ATSDR, 2003; Health Canada, 2010). Selenium aids in the defence of oxidative stress, the regulation of thyroid hormone action, and the regulation of the redox status of vitamin C and other molecules (IOM, 2000). Selenium deficiency seldom causes overt illness in isolation; however, it may lead to biochemical changes that predispose to illness associated with other stresses (IOM, 2000). On account of its essentiality, Health Canada has established recommended dietary allowances for selenium (Health Canada, 2010; IOM, 2000).

There is a narrow therapeutic window for selenium, and detrimental health effects can occur when ingested at levels greater than the tolerable upper intake level (Health Canada, 2010; IOM, 2000). The level at which selenium toxicity occurs is difficult to determine because it is affected by the types of protein in the diet, levels of vitamin E, and the forms of selenium to which the individual is exposed (Health Canada, 1992). Acute oral intake of selenium can result in nausea, vomiting, and diarrhea. Chronic levels of high selenium (10 to 20 times more than the recommended dietary allowances) can cause selenosis, a disease that results in hair loss, nail brittleness, and neurological abnormalities (ATSDR, 2003; IOM, 2000; WHO, 2011). Based on the available data, there is no evidence in humans of reproductive effects or developmental abnormalities (ATSDR, 2003). The International Agency for Research on Cancer has determined that selenium is not classifiable as to its carcinogenicity to humans (Group 3) (IARC, 1999). The role of selenium in other chronic diseases such as diabetes, hypertension, and cardiovascular disease is a subject of ongoing debate (Boosalis, 2008).

As part of the Chemicals Management Plan under the *Canadian Environmental Protection Act, 1999*, selenium-containing substances were identified as a priority group based on ecological concern (Canada, 1999; Canada, 2011a). Health Canada and Environment Canada are preparing a draft screening assessment report for publication in 2014–2015 (Canada, 2011b). Selenium and its compounds (except selenium sulfide) are included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011). In Canada, the leachable selenium content in a variety of consumer products is regulated under the *Canada Consumer Product Safety Act* (Canada, 2010a). Consumer products regulated for selenium content include paints and other surface coatings on cribs, toys, and other products for use by a child in learning or play situations (Canada, 2010b; Canada, 2011c). Health Canada has also set a maximum level for selenium in natural health products in Canada (Health Canada, 2007). Health Canada has developed a Canadian drinking water quality guideline that sets out the maximum acceptable concentration of selenium on the basis of health considerations; this guideline is currently under review (Health Canada, 1992). Tolerable upper intake levels for selenium, which account for its potential toxicity, have been developed by the Institute of Medicine and adopted by Health Canada (Health Canada, 2010; IOM, 2000). Selenium is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply.

In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric means for selenium in urine and whole blood were 63.19 µg/L and 221.17 µg/L, respectively (INSPQ, 2004).

Selenium was measured in the whole blood and urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented in blood as µg/L (Tables 8.13.1, 8.13.2, and 8.13.3) and in urine as both µg/L (Tables 8.13.4, 8.13.5, and 8.13.6) and µg/g creatinine (Tables 8.13.7, 8.13.8, and 8.13.9). Finding a measurable amount of selenium in blood or urine is an indicator of exposure to selenium and does not necessarily mean that an adverse health effect will occur. Because selenium is an essential trace element, its presence in biological fluids is expected.

Table 8.13.1

Selenium — Geometric means and selected percentiles of whole blood concentrations (μg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5319	0	200 (200 - 210)	160 (160 - 170)	190 (190 - 200)	210 (210 - 220)	250 (240 - 260)
Total, 6–79	2	5575	0	190 (190 - 190)	160 (150 - 160)	180 (180 - 190)	200 (200 - 210)	240 (230 - 250)
Males, Total 6–79	1	2576	0	200 (200 - 210)	170 (160 - 170)	200 (190 - 200)	220 (210 - 220)	250 (240 - 260)
Males, Total 6–79	2	2687	0	190 (190 - 200)	160 (160 - 160)	190 (180 - 190)	200 (200 - 210)	240 (230 - 260)
Females, Total 6–79	1	2743	0	200 (190 - 200)	160 (160 - 160)	190 (190 - 200)	210 (210 - 210)	250 (240 - 250)
Females, Total 6–79	2	2888	0	190 (180 - 190)	150 (150 - 160)	180 (180 - 190)	200 (200 - 210)	240 (230 - 250)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.13.2

Selenium — Geometric means and selected percentiles of whole blood concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6070	0	190 (190 - 190)	160 (150 - 160)	180 (180 - 190)	200 (200 - 210)	240 (230 - 250)
3–5[b]	1							
3–5	2	495	0	170 (160 - 170)	140 (140 - 150)	160 (160 - 170)	170 (170 - 180)	200 (200 - 210)
6–11	1	910	0	190 (180 - 190)	150 (150 - 160)	180 (180 - 180)	200 (190 - 200)	230 (220 - 230)
6–11	2	961	0	170 (170 - 180)	140 (140 - 150)	170 (160 - 170)	180 (180 - 190)	210 (200 - 220)
12–19	1	945	0	200 (190 - 200)	160 (160 - 170)	190 (190 - 190)	210 (200 - 210)	250 (240 - 260)
12–19	2	997	0	190 (180 - 190)	160 (150 - 160)	180 (180 - 180)	200 (190 - 200)	230 (220 - 240)
20–39	1	1165	0	200 (200 - 210)	160 (160 - 170)	200 (190 - 200)	210 (210 - 220)	250 (230 - 260)
20–39	2	1313	0	190 (190 - 200)	160 (150 - 160)	190 (180 - 190)	200 (200 - 210)	240 (220 - 270)
40–59	1	1220	0	200 (200 - 210)	170 (160 - 170)	200 (190 - 200)	220 (210 - 230)	250 (240 - 260)
40–59	2	1222	0	190 (190 - 200)	160 (150 - 160)	190 (180 - 190)	210 (210 - 210)	240 (240 - 250)
60–79	1	1079	0	200 (200 - 210)	170 (160 - 170)	200 (190 - 200)	220 (210 - 220)	250 (240 - 270)
60–79	2	1082	0	190 (190 - 190)	160 (150 - 160)	180 (180 - 190)	200 (200 - 210)	240 (230 - 240)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.13.3

Selenium — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2940	0	190 (190 - 190)	160 (160 - 160)	190 (180 - 190)	200 (200 - 210)	240 (230 - 260)
Males, 6–11	1	459	0	190 (180 - 190)	150 (150 - 160)	180 (180 - 180)	190 (190 - 200)	220 (210 - 240)
Males, 6–11	2	488	0	170 (170 - 180)	140 (140 - 150)	170 (160 - 170)	180 (180 - 190)	210 (200 - 220)
Males, 12–19	1	489	0	200 (190 - 200)	160 (160 - 170)	190 (180 - 190)	210 (200 - 220)	250 (230 - 260)
Males, 12–19	2	523	0	190 (180 - 190)	160 (150 - 160)	180 (180 - 190)	200 (190 - 200)	220 (190 - 250)
Males, 20–39	1	514	0	210 (200 - 210)	170 (170 - 170)	200 (190 - 200)	220 (210 - 230)	260 (240 - 290)
Males, 20–39	2	552	0	190 (190 - 200)	160 (160 - 170)	190 (180 - 190)	200 (200 - 210)	250 (220 - 280)
Males, 40–59	1	577	0	210 (200 - 210)	170 (160 - 180)	200 (190 - 210)	220 (220 - 230)	250 (240 - 260)
Males, 40–59	2	617	0	200 (190 - 200)	160 (160 - 170)	190 (190 - 200)	210 (210 - 210)	250 (230 - 270)
Males, 60–79	1	537	0	200 (200 - 210)	170 (160 - 180)	200 (190 - 210)	220 (210 - 230)	250 (240 - 270)
Males, 60–79	2	507	0	190 (190 - 190)	160 (160 - 160)	190 (180 - 190)	200 (200 - 200)	230 (220 - 240)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3130	0	190 (180 - 190)	150 (150 - 160)	180 (180 - 180)	200 (200 - 210)	240 (230 - 250)
Females, 6–11	1	451	0	190 (180 - 190)	150 (150 - 160)	180 (180 - 190)	200 (200 - 200)	230 (220 - 240)
Females, 6–11	2	473	0	180 (170 - 180)	140 (140 - 150)	170 (170 - 170)	190 (180 - 190)	220 (180 - 250)
Females, 12–19	1	456	0	190 (190 - 200)	160 (150 - 160)	190 (190 - 190)	210 (200 - 210)	250 (240 - 260)
Females, 12–19	2	474	0	180 (180 - 190)	160 (150 - 160)	180 (170 - 180)	200 (190 - 200)	230 (220 - 230)
Females, 20–39	1	651	0	200 (190 - 200)	160 (160 - 170)	190 (190 - 200)	210 (200 - 220)	240 (230 - 250)
Females, 20–39	2	761	0	190 (180 - 190)	150 (150 - 160)	180 (180 - 190)	200 (190 - 210)	230 (200 - 270)
Females, 40–59	1	643	0	200 (200 - 200)	160 (160 - 170)	190 (190 - 200)	210 (200 - 220)	250 (240 - 260)
Females, 40–59	2	605	0	190 (190 - 200)	150 (150 - 160)	190 (180 - 190)	210 (200 - 220)	240 (240 - 250)
Females, 60–79	1	542	0	200 (200 - 210)	160 (160 - 170)	190 (190 - 200)	220 (210 - 230)	250 (230 - 280)
Females, 60–79	2	575	0	190 (180 - 190)	150 (150 - 160)	180 (180 - 190)	200 (200 - 210)	240 (230 - 250)

[a] Breakdown by sex for the 3–5 year old age group is not recommended.

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[c] Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.13.4

Selenium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5492	0.46	49 (44 - 53)	17 (14 - 19)	53 (48 - 58)	85 (79 - 91)	140 (130 - 150)
Total, 6–79	2	5738	0.16	51 (49 - 53)	17 (15 - 20)	59 (55 - 62)	83 (78 - 87)	130 (130 - 140)
Males, Total 6–79	1	2662	0.23	57 (52 - 61)	21 (18 - 24)	62 (57 - 67)	94 (86 - 100)	150 (140 - 160)
Males, Total 6–79	2	2746	0.18	57 (54 - 60)	23 (21 - 25)	64 (60 - 69)	88 (81 - 96)	140 (130 - 160)
Females, Total 6–79	1	2830	0.67	42 (38 - 47)	13 (11 - 16)	44 (38 - 50)	75 (69 - 82)	130 (110 - 140)
Females, Total 6–79	2	2992	0.13	46 (43 - 48)	15 (13 - 17)	52 (49 - 55)	78 (76 - 80)	120 (110 - 140)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.13.5

Selenium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6311	0.14	51 (49 - 54)	18 (16 - 20)	59 (56 - 62)	83 (79 - 87)	130 (130 - 140)
3–5[b]	1							
3–5	2	573	0	61 (56 - 67)	29 (25 - 33)	64 (55 - 73)	89 (83 - 95)	140 (120 - 160)
6–11	1	1034	0.48	60 (54 - 67)	22 (18 - 26)	67 (60 - 74)	100 (93 - 110)	150 (140 - 160)
6–11	2	1062	0.09	67 (63 - 72)	29 (25 - 33)	71 (65 - 77)	97 (93 - 100)	150 (130 - 170)
12–19	1	983	0	62 (55 - 71)	22 (16 - 28)	70 (62 - 78)	100 (93 - 110)	160 (140 - 180)
12–19	2	1041	0	62 (56 - 67)	23 (18 - 29)	72 (65 - 78)	93 (87 - 98)	140 (130 - 140)
20–39	1	1169	0.77	48 (42 - 56)	17 (13 - 21)	53 (44 - 62)	84 (75 - 93)	140 (130 - 150)
20–39	2	1321	0.30	53 (48 - 59)	17 (12 - 22)	61 (56 - 67)	87 (80 - 93)	130 (120 - 150)
40–59	1	1223	0.74	45 (42 - 48)	14 (11 - 17)	48 (44 - 52)	83 (77 - 88)	130 (130 - 140)
40–59	2	1228	0.16	49 (46 - 53)	17 (12 - 22)	57 (51 - 62)	79 (75 - 83)	140 (120 - 160)
60–79	1	1083	0.18	45 (41 - 48)	17 (13 - 20)	49 (45 - 53)	72 (67 - 77)	120 (100 - 130)
60–79	2	1086	0.18	41 (39 - 44)	15 (13 - 16)	46 (42 - 51)	67 (63 - 71)	120 (100 - 130)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.13.6

Selenium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	0.16	57 (54 - 60)	23 (21 - 25)	64 (60 - 69)	89 (81 - 96)	140 (130 - 160)
Males, 6–11	1	524	0.38	62 (53 - 74)	23 (15 - 32)	68 (57 - 79)	100 (91 - 110)	160 (140 - 180)
Males, 6–11	2	532	0.19	72 (66 - 79)	38 (29 - 46)	74 (68 - 80)	100 (91 - 110)	150 (130 - 180)
Males, 12–19	1	505	0	66 (59 - 74)	26 (19 - 32)	71 (62 - 79)	100 (97 - 110)	160 (130 - 180)
Males, 12–19	2	542	0	68 (61 - 76)	30 (22 - 38)	76 (68 - 84)	97 (88 - 110)	140 (130 - 140)
Males, 20–39	1	514	0.58	55 (48 - 65)	18^{E} (10 - 26)	64 (55 - 73)	93 (83 - 100)	150 (120 - 180)
Males, 20–39	2	551	0.54	59 (53 - 66)	24 (18 - 31)	69 (62 - 76)	92 (81 - 100)	130 (110 - 140)
Males, 40–59	1	578	0.17	55 (52 - 59)	20 (18 - 22)	59 (52 - 66)	99 (92 - 110)	150 (140 - 160)
Males, 40–59	2	616	0	55 (49 - 61)	21 (16 - 26)	62 (54 - 70)	86 (73 - 98)	150 (130 - 170)
Males, 60–79	1	541	0	53 (49 - 58)	23 (20 - 25)	55 (51 - 60)	78 (67 - 89)	130 (120 - 140)
Males, 60–79	2	505	0.20	47 (43 - 51)	18 (14 - 22)	52 (47 - 57)	70 (66 - 75)	130 (110 - 140)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	0.12	46 (44 - 49)	15 (14 - 17)	52 (50 - 55)	78 (76 - 80)	120 (110 - 140)
Females, 6–11	1	510	0.59	58 (52 - 64)	20 (16 - 24)	66 (61 - 72)	99 (90 - 110)	140 (130 - 160)
Females, 6–11	2	530	0	63 (58 - 67)	27 (24 - 30)	65 (59 - 71)	92 (86 - 99)	140 (110 - 170)
Females, 12–19	1	478	0	59 (48 - 71)	19^{E} (9.4 - 30)	68 (57 - 79)	96 (90 - 100)	150 (130 - 180)
Females, 12–19	2	499	0	55 (49 - 62)	17^{E} (11 - 24)	66 (59 - 72)	87 (81 - 93)	140 (120 - 150)
Females, 20–39	1	655	0.92	42 (36 - 49)	16 (13 - 19)	42 (33 - 50)	72 (60 - 83)	130 (110 - 150)
Females, 20–39	2	770	0.13	48 (41 - 56)	16 (13 - 19)	53 (45 - 60)	82 (74 - 90)	140 (95 - 180)
Females, 40–59	1	645	1.24	37 (33 - 40)	12 (9.3 - 14)	39 (34 - 45)	68 (62 - 73)	110 (100 - 120)
Females, 40–59	2	612	0.33	44 (41 - 47)	12^{E} (6.9 - 18)	52 (47 - 56)	77 (70 - 85)	120 (100 - 130)
Females, 60–79	1	542	0.37	38 (33 - 43)	13 (10 - 16)	40 (32 - 48)	66 (59 - 72)	110 (97 - 120)
Females, 60–79	2	581	0.17	37 (33 - 41)	13 (8.3 - 17)	40 (35 - 45)	64 (57 - 71)	100 (92 - 110)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.13.7

Selenium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5479	0.46	59 (56 - 62)	34 (32 - 36)	57 (54 - 61)	77 (72 - 81)	120 (110 - 130)
Total, 6–79	2	5719	0.16	48 (46 - 50)	30 (28 - 31)	46 (45 - 48)	60 (58 - 61)	96 (88 - 100)
Males, Total 6–79	1	2653	0.23	56 (53 - 59)	32 (30 - 34)	54 (52 - 57)	73 (68 - 79)	110 (97 - 130)
Males, Total 6–79	2	2739	0.18	45 (44 - 47)	29 (27 - 31)	44 (42 - 46)	56 (54 - 59)	90 (86 - 94)
Females, Total 6–79	1	2826	0.67	62 (59 - 65)	36 (34 - 38)	61 (58 - 64)	80 (76 - 85)	130 (120 - 130)
Females, Total 6–79	2	2980	0.13	50 (48 - 52)	30 (29 - 32)	50 (48 - 52)	64 (60 - 68)	100 (91 - 110)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.13.8

Selenium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6291	0.14	49 (47 - 51)	30 (28 - 31)	47 (46 - 49)	62 (59 - 65)	100 (95 - 110)
3–5[b]	1							
3–5	2	572	0	100 (99 - 110)	66 (61 - 71)	100 (96 - 110)	130 (120 - 140)	190 (160 - 210)
6–11	1	1031	0.48	92 (89 - 96)	55 (51 - 59)	93 (89 - 98)	110 (110 - 120)	170 (150 - 180)
6–11	2	1058	0.09	76 (72 - 80)	47 (45 - 49)	74 (70 - 79)	98 (93 - 100)	160 (130 - 180)
12–19	1	982	0	54 (51 - 58)	32 (30 - 34)	53 (49 - 57)	69 (63 - 74)	110 (91 - 120)
12–19	2	1039	0	46 (44 - 48)	31 (29 - 33)	44 (42 - 46)	57 (53 - 60)	86 (79 - 92)
20–39	1	1165	0.77	54 (51 - 57)	32 (29 - 35)	52 (48 - 55)	69 (64 - 75)	100 (86 - 120)
20–39	2	1319	0.30	44 (42 - 46)	27 (25 - 29)	43 (41 - 45)	55 (52 - 58)	81 (71 - 91)
40–59	1	1218	0.74	58 (54 - 61)	33 (30 - 36)	56 (53 - 60)	74 (69 - 79)	110 (99 - 120)
40–59	2	1223	0.16	47 (45 - 50)	30 (29 - 32)	46 (43 - 50)	59 (56 - 61)	86 (80 - 92)
60–79	1	1083	0.18	62 (59 - 66)	39 (36 - 42)	62 (58 - 65)	79 (75 - 83)	120 (100 - 130)
60–79	2	1080	0.19	49 (47 - 51)	30 (28 - 33)	48 (46 - 50)	60 (57 - 64)	95 (85 - 110)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.13.9

Selenium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	0.17	47 (45 - 49)	29 (27 - 31)	45 (43 - 47)	58 (56 - 60)	99 (94 - 100)
Males, 6–11	1	522	0.38	95 (91 - 99)	59 (56 - 62)	96 (91 - 100)	110 (110 - 120)	170 (150 - 180)
Males, 6–11	2	530	0.19	79 (73 - 85)	48 (44 - 52)	75 (70 - 81)	100 (88 - 110)	170 (130 - 210)
Males, 12–19	1	504	0	56 (52 - 60)	32 (29 - 36)	55 (52 - 57)	71 (64 - 77)	120 (88 - 140)
Males, 12–19	2	541	0	46 (44 - 48)	30 (27 - 32)	45 (42 - 48)	59 (54 - 63)	86 (81 - 92)
Males, 20–39	1	512	0.59	51 (47 - 55)	29 (25 - 32)	49 (46 - 52)	67 (61 - 73)	100 (80 - 120)
Males, 20–39	2	550	0.55	41 (38 - 44)	26 (23 - 30)	42 (40 - 45)	51 (48 - 54)	80 (70 - 91)
Males, 40–59	1	574	0.17	55 (51 - 59)	32 (29 - 35)	53 (49 - 57)	69 (61 - 77)	100 (87 - 120)
Males, 40–59	2	615	0	44 (41 - 47)	30 (28 - 32)	43 (40 - 46)	53 (49 - 58)	76 (67 - 85)
Males, 60–79	1	541	0	56 (52 - 60)	35 (32 - 39)	55 (50 - 59)	70 (63 - 77)	100 (85 - 120)
Males, 60–79	2	503	0.20	45 (43 - 48)	30 (28 - 32)	44 (42 - 46)	54 (51 - 58)	84 (72 - 96)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	0.12	52 (50 - 54)	31 (29 - 33)	51 (49 - 53)	66 (61 - 70)	110 (100 - 120)
Females, 6–11	1	509	0.59	90 (85 - 95)	51 (46 - 56)	89 (84 - 95)	110 (100 - 120)	170 (140 - 210)
Females, 6–11	2	528	0	74 (71 - 77)	46 (42 - 49)	73 (68 - 78)	96 (91 - 100)	140 (120 - 160)
Females, 12–19	1	478	0	53 (49 - 57)	32 (30 - 34)	52 (46 - 57)	66 (59 - 73)	100 (87 - 120)
Females, 12–19	2	498	0	46 (43 - 48)	32 (29 - 34)	44 (41 - 47)	55 (50 - 59)	81 (63 - 99)
Females, 20–39	1	653	0.92	58 (54 - 62)	36 (34 - 38)	55 (51 - 59)	72 (66 - 79)	110 (89 - 130)
Females, 20–39	2	769	0.13	47 (44 - 50)	28 (25 - 32)	46 (42 - 51)	60 (56 - 64)	88 (60 - 120)
Females, 40–59	1	644	1.24	61 (57 - 65)	35 (31 - 39)	62 (58 - 66)	79 (71 - 88)	120 (98 - 140)
Females, 40–59	2	608	0.33	51 (47 - 54)	31 (28 - 33)	51 (46 - 56)	65 (58 - 71)	95 (78 - 110)
Females, 60–79	1	542	0.37	69 (66 - 72)	42 (39 - 46)	67 (63 - 71)	87 (81 - 92)	130 (120 - 150)
Females, 60–79	2	577	0.17	52 (49 - 55)	31 (26 - 36)	51 (49 - 53)	64 (60 - 69)	100 (82 - 120)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

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8.14 SILVER

Silver (CASRN 7440-22-4) is a rare naturally occurring element found in the Earth's crust at an average concentration of approximately 0.000007% (Emsley, 2001). In its pure form, silver is a white lustrous metal with physical properties including ductility, electrical conductivity, malleability, and reflectivity. Natural silver is found in the environment in its pure form and in ores such as argentite, horn silver, chlorargyrite, and pyrargyritein.

Silver is naturally released into the environment through weathering and erosion of rocks and soil. Anthropogenic sources of silver include base-metal smelting, metal mining, cement manufacturing, burning of fossil fuels, hazardous waste sites, sewage, and silver–iodine cloud seeding (WHO, 2002). Photographic processing and materials were once the primary sources for environmental releases of silver; however, with the advent of digital photography, this use of silver has declined (USGS, 2012). Recent applications of nanosilver as an antimicrobial in a wide variety of products from household appliances to personal-care products are a potentially significant new source of release (Luoma, 2008).

Silver has been traditionally used in coins and medals, industrial applications, jewellery, silverware, and photography (USGS, 2011). Historically, in Canada, the major uses of silver were photography and coin production (Health Canada, 1986). Current industrial applications of silver include batteries, brazing and soldering, automobile catalytic converters, electronics and circuit boards, electroplating, hardening bearings, inks, mirrors, and solar cells (USGS, 2011). Soluble silver compounds are toxic to some bacteria, viruses, algae, and fungi. The antimicrobial properties of silver have led to the development of various applications including its use in bandages for wound care, cellphone covers to reduce the spread of bacteria, clothing to minimize odour, water purification, and wood treatment to resist mould (USGS, 2011).

Silver exposure occurs primarily through food and drinking water, although exposure can also come from air (ATSDR, 1990). Because many silver salts are sparingly soluble, dissolved silver concentrations in natural waters are very low (Health Canada, 1986).

Based on a variety of mammalian data, the World Health Organization has estimated that approximately 10% of ingested silver is absorbed (WHO, 2003). Absorption of silver compounds from dermal exposure is much less efficient than from inhalation or ingestion because silver compounds are not readily absorbed through intact skin (ATSDR, 1990). Once absorbed, silver is stored primarily in liver and skin and in smaller amounts in other organs (WHO, 2003). Laboratory studies have indicated that silver is excreted following a triphasic profile with biological half-lives of a few hours, several days, and weeks to months (ATSDR, 1990). The majority of absorbed silver is excreted within a week predominantly through feces with a smaller amount through urine (ATSDR, 1990). The most common tests for silver exposure are through sampling of feces and blood (ATSDR, 1990). Urine can also be sampled; however, silver has not always been detected in urine samples from workers with known exposure to the metal, and as such is not as reliable a biomarker as feces and blood (ATSDR, 1990).

No reports of adverse health effects have been associated with exposure to silver at levels normally encountered in diets (Health Canada, 1986). There is human evidence of chronic toxicity following use of silver compounds as therapeutic agents (Health Canada, 1986). Ingestion of excessive quantities or prolonged administration of silver-containing compounds may result in argyria, a condition characterized by blue-grey discoloration of the skin, eyes, and mucous membranes (Health Canada, 1986).

Silver is not regarded as having any carcinogenic effects in humans (ATSDR, 1990). Evidence linking ingested silver or silver compounds with carcinogenic, mutagenic, or teratogenic effects is lacking, and silver has not been classified with respect to its carcinogenicity by the International Agency for Research on Cancer or Health Canada (Health Canada, 1986).

Health Canada has concluded that daily intake of silver from food and water is considerably below the level at which adverse effects would occur; therefore, a maximum acceptable concentration in drinking water has not been specified (Health Canada, 1986).

Silver was measured in the whole blood and urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and is presented in blood as µg/L (Tables 8.14.1 and 8.14.2) and in urine as both µg/L and µg/g creatinine (Tables 8.14.3, 8.14.4, 8.14.5, and 8.14.6). Finding a measurable amount of silver in blood or urine is an indicator of exposure to silver and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for blood and urinary silver in the Canadian population.

Table 8.14.1

Silver — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6070	45.78	—	<LOD	0.066 (<LOD - 0.088)	0.10 (0.097 - 0.11)	0.27 (0.22 - 0.31)
3–5	2	495	61.21	—	<LOD	<LOD	0.084 (0.060 - 0.11)	0.19^{E} (0.095 - 0.28)
6–11	2	961	60.35	—	<LOD	<LOD	0.075 (0.052 - 0.099)	F
12–19	2	997	57.27	—	<LOD	<LOD	0.082 (0.058 - 0.11)	0.16^{E} (0.070 - 0.24)
20–39	2	1313	39.98	0.071 (0.058 - 0.088)	<LOD	0.068 (<LOD - 0.090)	0.10 (0.091 - 0.11)	0.26 (0.21 - 0.30)
40–59	2	1222	33.22	0.080 (0.066 - 0.097)	<LOD	0.083 (0.058 - 0.11)	0.10 (0.098 - 0.11)	0.32 (0.22 - 0.42)
60–79	2	1082	36.41	0.078 (0.062 - 0.098)	<LOD	0.080 (0.054 - 0.11)	0.10 (0.093 - 0.12)	0.32 (0.28 - 0.36)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.14.2

Silver — Geometric means and selected percentiles of whole blood concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	2940	49.59	—	<LOD	0.060[E] (<LOD - 0.086)	0.10 (0.090 - 0.11)	0.22 (0.19 - 0.24)
Males, 6–11	2	488	61.89	—	<LOD	<LOD	0.063 (<LOD - 0.085)	F
Males, 12–19	2	523	62.52	—	<LOD	<LOD	0.077 (0.055 - 0.098)	0.11[E] (0.064 - 0.15)
Males, 20–39	2	552	47.64	—	<LOD	0.059[E] (<LOD - 0.088)	0.099 (0.079 - 0.12)	0.21 (0.19 - 0.24)
Males, 40–59	2	617	35.66	0.075 (0.060 - 0.093)	<LOD	0.079 (0.051 - 0.11)	0.10 (0.099 - 0.11)	0.27[E] (0.17 - 0.38)
Males, 60–79	2	507	36.69	0.070 (0.057 - 0.088)	<LOD	0.071 (<LOD - 0.094)	0.10 (0.096 - 0.11)	0.26 (0.21 - 0.31)
Females, Total 3–79	2	3130	42.20	—	<LOD	0.074 (0.052 - 0.096)	0.10 (0.10 - 0.11)	0.32 (0.27 - 0.37)
Females, 6–11	2	473	58.77	—	<LOD	<LOD	0.083 (0.061 - 0.10)	0.11[E] (0.051 - 0.16)
Females, 12–19	2	474	51.48	—	<LOD	<LOD	0.088 (0.063 - 0.11)	0.19[E] (0.091 - 0.29)
Females, 20–39	2	761	34.43	0.081 (0.065 - 0.10)	<LOD	0.076 (0.054 - 0.098)	0.11[E] (0.055 - 0.16)	0.32 (0.25 - 0.38)
Females, 40–59	2	605	30.74	0.085 (0.071 - 0.10)	<LOD	0.087 (0.067 - 0.11)	0.11[E] (0.050 - 0.16)	0.35[E] (0.22 - 0.49)
Females, 60–79	2	575	36.17	0.086 (0.066 - 0.11)	<LOD	0.091 (0.060 - 0.12)	0.11[E] (<LOD - 0.17)	0.35 (0.28 - 0.42)

[a] Breakdown by sex for the 3–5 year old age group is not recommended.

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[E] Use data with caution.

F Data is too unreliable to be published.

Table 8.14.3

Silver — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6311	92.35	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.11)
3–5	2	573	91.10	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.13)
6–11	2	1062	90.21	—	<LOD	<LOD	<LOD	0.12[E] (<LOD - 0.19)
12–19	2	1041	90.68	—	<LOD	<LOD	<LOD	0.11[E] (<LOD - 0.17)
20–39	2	1321	92.66	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.13)
40–59	2	1228	93.32	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.11)
60–79	2	1086	95.21	—	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[E] Use data with caution.

Table 8.14.4

Silver — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	3036	92.16	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.11)
Males, 6–11	2	532	91.73	—	<LOD	<LOD	<LOD	F
Males, 12–19	2	542	90.04	—	<LOD	<LOD	<LOD	0.12[E] (<LOD - 0.20)
Males, 20–39	2	551	92.20	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.11)
Males, 40–59	2	616	92.69	—	<LOD	<LOD	<LOD	<LOD
Males, 60–79	2	505	94.46	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.10)
Females, Total 3–79	2	3275	92.52	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.13)
Females, 6–11	2	530	88.68	—	<LOD	<LOD	<LOD	0.12[E] (<LOD - 0.18)
Females, 12–19	2	499	91.38	—	<LOD	<LOD	<LOD	0.10[E] (<LOD - 0.15)
Females, 20–39	2	770	92.99	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.17)
Females, 40–59	2	612	93.95	—	<LOD	<LOD	<LOD	F
Females, 60–79	2	581	95.87	—	<LOD	<LOD	<LOD	<LOD

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.14.5

Silver (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6291	92.64	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.29)
3–5	2	572	91.26	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.41)
6–11	2	1058	90.55	—	<LOD	<LOD	<LOD	0.24[E] (<LOD - 0.33)
12–19	2	1039	90.86	—	<LOD	<LOD	<LOD	0.17 (<LOD - 0.23)
20–39	2	1319	92.80	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.42)
40–59	2	1223	93.70	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.29)
60–79	2	1080	95.74	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.14.6

Silver (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	3028	92.40	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.23)
Males, 6–11	2	530	92.08	—	<LOD	<LOD	<LOD	F
Males, 12–19	2	541	90.20	—	<LOD	<LOD	<LOD	0.16 (<LOD - 0.21)
Males, 20–39	2	550	92.36	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.30)
Males, 40–59	2	615	92.85	—	<LOD	<LOD	<LOD	<LOD
Males, 60–79	2	503	94.83	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.24)
Females, Total 3–79	2	3263	92.86	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.37)
Females, 6–11	2	528	89.02	—	<LOD	<LOD	<LOD	0.24 (<LOD - 0.29)
Females, 12–19	2	498	91.57	—	<LOD	<LOD	<LOD	0.22 (<LOD - 0.29)
Females, 20–39	2	769	93.11	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.60)
Females, 40–59	2	608	94.57	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.40)
Females, 60–79	2	577	96.53	—	<LOD	<LOD	<LOD	<LOD

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

F Data is too unreliable to be published.

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8.15 THALLIUM

Thallium (CASRN 7440-28-0) is a blue-white, soft, malleable, naturally occurring metal present in the Earth's crust at an average concentration of approximately 0.00007% (USGS, 2011). It is ubiquitous in the environment and primarily occurs in the sulphide ores of a number of trace metals including copper, lead, and zinc. Thallium can also combine with other substances such as sulphide, chloride, and bromide to form salts, most of which are soluble in water (ATSDR, 1992).

Thallium is naturally released into the environment through weathering processes (CCME, 1999a). In addition to natural sources, thallium is released into the environment through anthropogenic emissions and waste materials from the combustion of fossil fuels, cement production, base-metal mining, and smelting (USGS, 2011). The major sources of thallium in drinking water are leaching from ore-processing sites and discharge from electronics, glass, and drug factories.

Thallium is used in alloys, electrodes, low-melting and highly refractive glass, cardiac imaging, electroplating, and as a high-temperature superconducting compound (CCME, 1999a). Historically, thallium was used in pesticides, but accidental poisonings and misuse have led to the ban or restriction of this use in most countries including Canada (CCME, 1999b). Thallium salts were also previously used as a depilatory agent and in the treatment of tuberculosis, malaria, and venereal diseases. However, as a consequence of adverse effects related to thallium, these uses have been discontinued (WHO, 1996).

Although only trace amounts of thallium are found in the environment, its presence is widespread, and humans are exposed daily via food and to a lesser degree through air and water (ATSDR, 1992). Thallous compounds have high solubility in water and are transported relatively easily into the environment through water. This fact is of concern because conventional water treatment strategies do little to remove thallium from water (Peter & Viraraghavan, 2005).

Thallium can be absorbed following ingestion, inhalation, or dermal contact. Following inhalation, it is generally assumed that up to 100% of lung-deposited thallium is absorbed (WHO, 1996). Similarly, studies suggest that thallium is completely absorbed following ingestion (ATSDR, 1992). Once absorbed, thallium is rapidly distributed throughout the body and accumulates in bones, kidneys. and eventually in the central nervous system (Peter & Viraraghavan, 2005). Thallium is primarily excreted in urine and to a lesser extent in feces, with a biological half-life of 3 to 8 days (ATSDR, 1992; Peter & Viraraghavan, 2005). Urinary thallium levels can be used as biomarkers of recent thallium exposure (CDC, 2009).

Thallium is a highly toxic element and is considered more acutely toxic than mercury, cadmium, lead, zinc, or copper. Adverse effects of acute thallium exposure include gastroenteritis, polyneuropathy, and alopecia (Peter & Viraraghavan, 2005). Based on human case reports and animal studies, the nervous system is considered the target organ of thallium (EPA, 2009). Information regarding the effects of low-level chronic exposure to thallium is limited. Some human data from the mining industry suggest that workers chronically exposed to thallium experienced headaches, anorexia, and pain in the arms, thighs, and abdomen (Peter & Viraraghavan, 2005).

Presently, there are no studies that evaluate the carcinogenic potential of thallium in animals and no sufficient evidence from workers occupationally exposed to thallium (EPA, 2009). Based on available data, thallium is not considered mutagenic or teratogenic, and data available on the reproductive effects of thallium on humans are limited (Peter & Viraraghavan, 2005). The International Agency for Research on Cancer considers the evidence for the carcinogenicity of thallium as unclassifiable.

As part of the Chemicals Management Plan under the *Canadian Environmental Protection Act, 1999*, thallium chloride is a priority for future assessment based on ecological concern (Canada, 1999; Environment Canada, 2011). There is currently no Canadian guideline for thallium in drinking water (Health Canada, 2012). Thallium is included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply.

In a biomonitoring study carried out in the region of the city of Québec with 500 participants aged 18 to 65 years, the geometric mean of thallium in urine was 0.21 µg/L (INSPQ, 2004).

Thallium was measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and is presented as both µg/L and µg/g creatinine (Tables 8.15.1, 8.15.2, 8.15.3, and 8.15.4). Finding a measurable amount of thallium in urine is an indicator of exposure to thallium and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary thallium in the Canadian population.

Table 8.15.1

Thallium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6311	0.43	0.23 (0.21 - 0.24)	0.085 (0.077 - 0.093)	0.24 (0.22 - 0.26)	0.37 (0.34 - 0.40)	0.62 (0.55 - 0.70)
3–5	2	573	0.35	0.27 (0.23 - 0.30)	0.12 (0.11 - 0.14)	0.26 (0.23 - 0.29)	0.40 (0.35 - 0.44)	0.65 (0.43 - 0.86)
6–11	2	1062	0.19	0.26 (0.24 - 0.28)	0.11 (0.096 - 0.13)	0.27 (0.25 - 0.29)	0.38 (0.35 - 0.41)	0.59 (0.50 - 0.67)
12–19	2	1041	0.29	0.25 (0.23 - 0.28)	0.097 (0.073 - 0.12)	0.27 (0.24 - 0.29)	0.40 (0.36 - 0.44)	0.61 (0.52 - 0.69)
20–39	2	1321	0.61	0.25 (0.22 - 0.27)	0.10 (0.081 - 0.12)	0.25 (0.23 - 0.28)	0.40 (0.35 - 0.44)	0.65 (0.57 - 0.73)
40–59	2	1228	0.49	0.23 (0.20 - 0.25)	0.080 (0.066 - 0.094)	0.25 (0.21 - 0.28)	0.37 (0.32 - 0.42)	0.69 (0.55 - 0.83)
60–79	2	1086	0.55	0.17 (0.16 - 0.19)	0.057 (0.041 - 0.074)	0.19 (0.17 - 0.21)	0.27 (0.25 - 0.29)	0.44 (0.39 - 0.49)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.15.2

Thallium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	3036	0.36	0.24 (0.23 - 0.26)	0.097 (0.085 - 0.11)	0.26 (0.23 - 0.28)	0.40 (0.35 - 0.44)	0.67 (0.58 - 0.77)
Males, 6–11	2	532	0.19	0.26 (0.24 - 0.28)	0.14 (0.11 - 0.16)	0.26 (0.24 - 0.28)	0.37 (0.32 - 0.42)	0.57 (0.45 - 0.68)
Males, 12–19	2	542	0.18	0.28 (0.25 - 0.32)	0.12 (0.086 - 0.15)	0.30 (0.25 - 0.35)	0.43 (0.38 - 0.48)	0.61 (0.49 - 0.73)
Males, 20–39	2	551	0.54	0.25 (0.22 - 0.29)	0.10 (0.074 - 0.13)	0.27 (0.23 - 0.32)	0.41 (0.36 - 0.45)	0.66 (0.57 - 0.75)
Males, 40–59	2	616	0.49	0.25 (0.21 - 0.29)	0.085 (0.062 - 0.11)	0.27 (0.23 - 0.31)	0.44 (0.35 - 0.52)	0.75 (0.59 - 0.90)
Males, 60–79	2	505	0.20	0.19 (0.17 - 0.21)	0.080 (0.064 - 0.097)	0.20 (0.18 - 0.22)	0.28 (0.25 - 0.31)	0.51 (0.42 - 0.60)
Females, Total 3–79	2	3275	0.49	0.21 (0.20 - 0.23)	0.080 (0.068 - 0.092)	0.22 (0.20 - 0.24)	0.34 (0.32 - 0.37)	0.59 (0.53 - 0.65)
Females, 6–11	2	530	0.19	0.25 (0.22 - 0.29)	0.092 (0.074 - 0.11)	0.28 (0.25 - 0.31)	0.39 (0.32 - 0.45)	0.62 (0.51 - 0.73)
Females, 12–19	2	499	0.40	0.23 (0.20 - 0.25)	F	0.25 (0.23 - 0.27)	0.34 (0.32 - 0.37)	0.59 (0.50 - 0.69)
Females, 20–39	2	770	0.65	0.24 (0.21 - 0.27)	0.098 (0.077 - 0.12)	0.24 (0.21 - 0.26)	0.38 (0.31 - 0.44)	0.62 (0.47 - 0.77)
Females, 40–59	2	612	0.49	0.20 (0.18 - 0.23)	0.061[E] (0.029 - 0.092)	0.21 (0.17 - 0.25)	0.35 (0.32 - 0.37)	0.60 (0.48 - 0.73)
Females, 60–79	2	581	0.86	0.16 (0.14 - 0.17)	0.051 (0.044 - 0.058)	0.17 (0.14 - 0.19)	0.26 (0.23 - 0.29)	0.42 (0.40 - 0.44)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.15.3

Thallium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6291	0.43	0.22 (0.20 - 0.23)	0.11 (0.10 - 0.12)	0.21 (0.20 - 0.23)	0.30 (0.28 - 0.32)	0.55 (0.49 - 0.61)
3–5	2	572	0.35	0.45 (0.40 - 0.51)	0.24 (0.19 - 0.28)	0.47 (0.41 - 0.53)	0.60 (0.53 - 0.67)	1.0 (0.80 - 1.3)
6–11	2	1058	0.19	0.29 (0.27 - 0.31)	0.15 (0.13 - 0.16)	0.29 (0.27 - 0.31)	0.41 (0.37 - 0.44)	0.64 (0.59 - 0.70)
12–19	2	1039	0.29	0.19 (0.18 - 0.20)	0.10 (0.093 - 0.11)	0.19 (0.18 - 0.20)	0.26 (0.24 - 0.28)	0.40 (0.36 - 0.44)
20–39	2	1319	0.61	0.20 (0.19 - 0.22)	0.11 (0.090 - 0.12)	0.20 (0.17 - 0.22)	0.28 (0.25 - 0.30)	0.48 (0.39 - 0.56)
40–59	2	1223	0.49	0.22 (0.20 - 0.24)	0.12 (0.11 - 0.13)	0.22 (0.21 - 0.23)	0.30 (0.27 - 0.33)	0.52 (0.39 - 0.65)
60–79	2	1080	0.56	0.20 (0.19 - 0.22)	0.11 (0.10 - 0.12)	0.20 (0.18 - 0.21)	0.28 (0.25 - 0.31)	0.47 (0.42 - 0.52)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.15.4

Thallium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	3028	0.36	0.20 (0.19 - 0.21)	0.11 (0.098 - 0.11)	0.20 (0.18 - 0.21)	0.28 (0.26 - 0.30)	0.49 (0.42 - 0.57)
Males, 6–11	2	530	0.19	0.28 (0.26 - 0.31)	0.14 (0.12 - 0.16)	0.29 (0.25 - 0.32)	0.40 (0.34 - 0.46)	0.61 (0.54 - 0.68)
Males, 12–19	2	541	0.18	0.19 (0.17 - 0.21)	0.11 (0.094 - 0.12)	0.18 (0.16 - 0.21)	0.26 (0.24 - 0.28)	0.38 (0.33 - 0.42)
Males, 20–39	2	550	0.55	0.18 (0.16 - 0.20)	0.097 (0.084 - 0.11)	0.18 (0.16 - 0.20)	0.25 (0.22 - 0.28)	0.35 (0.30 - 0.41)
Males, 40–59	2	615	0.49	0.20 (0.18 - 0.22)	0.11 (0.096 - 0.12)	0.20 (0.18 - 0.22)	0.28 (0.23 - 0.33)	0.48 (0.34 - 0.61)
Males, 60–79	2	503	0.20	0.19 (0.17 - 0.20)	0.11 (0.095 - 0.12)	0.18 (0.17 - 0.20)	0.25 (0.22 - 0.28)	0.40 (0.34 - 0.45)
Females, Total 3–79	2	3263	0.49	0.24 (0.22 - 0.25)	0.12 (0.11 - 0.13)	0.23 (0.21 - 0.24)	0.33 (0.29 - 0.36)	0.59 (0.52 - 0.66)
Females, 6–11	2	528	0.19	0.30 (0.27 - 0.33)	0.15 (0.13 - 0.17)	0.30 (0.27 - 0.33)	0.41 (0.35 - 0.46)	0.66 (0.57 - 0.75)
Females, 12–19	2	498	0.40	0.19 (0.17 - 0.20)	0.098 (<LOD - 0.11)	0.19 (0.17 - 0.20)	0.26 (0.23 - 0.28)	0.41 (0.35 - 0.46)
Females, 20–39	2	769	0.65	0.23 (0.21 - 0.27)	0.12 (0.099 - 0.14)	0.21 (0.19 - 0.24)	0.31 (0.25 - 0.37)	0.57 (0.45 - 0.70)
Females, 40–59	2	608	0.49	0.24 (0.22 - 0.26)	0.13 (0.11 - 0.15)	0.23 (0.20 - 0.25)	0.31 (0.28 - 0.34)	0.56 (0.36 - 0.76)
Females, 60–79	2	577	0.87	0.22 (0.20 - 0.24)	0.12 (0.10 - 0.14)	0.22 (0.19 - 0.25)	0.32 (0.28 - 0.35)	0.51 (0.46 - 0.57)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

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8.16 TUNGSTEN

Tungsten (CASRN 7440-33-7) is a steel grey metal present in the Earth's crust at average concentrations ranging from 0.00001% to 0.00024% (ATSDR, 2005). In its pure form the metal can be easily shaped, but in the presence of impurities it is often brittle and hard. Tungsten is relatively stable in the environment (Langard, 2001). Five stable and 28 radioactive isotopes of tungsten are currently known. In nature, tungsten occurs in minerals combined with other elements but not as a pure metal.

Tungsten particles are released into the atmosphere by both natural and anthropogenic sources. Tungsten is naturally present in soils and sediments and is released to air and water through soil erosion and leaching from soil and rocks (ATSDR, 2005). Anthropogenic sources include emissions from metal milling and processing, waste and fuel burning, mining operations, and fertilizer application (ATSDR, 2005). Military training and combat operations also release tungsten during the use of tungsten-containing weaponry (ATSDR, 2005).

The major uses of tungsten include the production of cutting and wear-resistance materials, mill products, alloy additives, super alloys, and tungsten chemicals (Langard, 2001). Commercial applications of tungsten, primarily in the tungsten carbide form, include uses as a component in cutting, forming, mining, and drilling tools (ATSDR, 2005). Tungsten metal powder is used for the production of filament wire, welding rods, and coating oil-well tools. Tungsten alloys have also been increasingly used in military weaponry as a replacement for depleted uranium and lead-based munitions (EPA, 2010; Health Canada, 2008). Tungsten metal is also a component in the production of golf clubs, counterbalance weights, lamp filaments, furnace elements, glass-melting equipment, high-speed rotors, and aerospace applications, including rocket nozzles. Tungsten compounds may be used as a part of pigments, printing inks, waxes, glasses, and cigarette filters as well as fireproofing agents in textiles (ATSDR, 2005).

The general population can be exposed to trace amounts of tungsten in food, drinking water, and air (ATSDR, 2005). Exposure to tungsten-containing compounds, rather than to tungsten itself, may occur during the use of tungsten, its alloys, and compounds. Based on limited surface-water data, the estimated daily intake from drinking water is expected to be negligible (ATSDR, 2005).

Following ingestion or inhalation, approximately half of soluble tungsten compounds are absorbed into the blood stream (ATSDR, 2005). The majority of absorbed tungsten is rapidly released in the urine (ATSDR, 2005). Studies in animals indicate that bone is the main reservoir for tungsten following long-term distribution in the body (Langard, 2001). The presence of tungsten in the blood, urine, or feces serves as a biomarker of exposure to tungsten or tungsten compounds, with urinary levels reflective of recent exposure (ATSDR, 2005; CDC, 2009).

The toxicity of ingested tungsten in humans is unknown (ATSDR, 2005). Data following inhalation exposure are available only for occupational exposures in the hard-metal industry. It is unclear, however, whether the illnesses observed stem from exposure to tungsten alone or rather cobalt mixed with tungsten carbide (ATSDR, 2005). No other significant adverse health effects have been associated with acute or chronic inhalation, oral, or dermal exposure to tungsten or tungsten compounds in humans (ATSDR, 2005). In laboratory animals, there is limited evidence associating oral or inhalation tungsten exposure with reproductive and developmental effects (ATSDR, 2005). Skin and eye irritations have also been observed in animals following exposure to tungsten chloride (ATSDR, 2005).

The International Agency for Research on Cancer (IARC) concluded that cobalt metal with tungsten carbide is probably carcinogenic to humans (Group 2A) (IARC, 2006). Evidence for the carcinogenicity of tungsten alone is lacking and it has not been classified with respect to its carcinogenicity by IARC (ITER, 2010).

Health Canada has not established a drinking water quality guideline for tungsten (Health Canada, 2012).

Tungsten was measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and is presented as both µg/L and µg/g creatinine (Tables 8.16.1, 8.16.2, 8.16.3, and 8.16.4). Finding a measurable amount of tungsten in urine is an indicator of exposure to tungsten and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary tungsten in the Canadian population.

Table 8.16.1

Tungsten — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6310	65.63	—	<LOD	<LOD	<LOD	0.63 (0.50 - 0.76)
3–5	2	573	46.95	—	<LOD	<LOD	0.33 (0.27 - 0.40)	1.2[E] (0.61 - 1.8)
6–11	2	1062	49.53	—	<LOD	<LOD	0.29 (0.24 - 0.35)	0.98 (0.67 - 1.3)
12–19	2	1040	53.27	—	<LOD	<LOD	0.28 (0.22 - 0.33)	0.85 (0.64 - 1.1)
20–39	2	1321	70.40	—	<LOD	<LOD	<LOD (<LOD - 0.21)	0.63 (0.41 - 0.85)
40–59	2	1228	78.50	—	<LOD	<LOD	<LOD	0.48 (0.36 - 0.60)
60–79	2	1086	82.69	—	<LOD	<LOD	<LOD	0.33 (0.24 - 0.43)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.16.2

Tungsten — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	3036	62.65	—	<LOD	<LOD	<LOD	0.65 (0.50 - 0.80)
Males, 6–11	2	532	47.37	—	<LOD	<LOD	0.33 (0.22 - 0.44)	1.2[E] (0.66 - 1.8)
Males, 12–19	2	542	49.82	—	<LOD	<LOD	0.31 (0.24 - 0.36)	0.91[E] (0.55 - 1.3)
Males, 20–39	2	551	67.51	—	<LOD	<LOD	<LOD (<LOD - 0.23)	F
Males, 40–59	2	616	76.30	—	<LOD	<LOD	<LOD	0.48 (0.35 - 0.62)
Males, 60–79	2	505	80.00	—	<LOD	<LOD	<LOD	0.34[E] (<LOD - 0.50)
Females, Total 3–79	2	3274	68.39	—	<LOD	<LOD	<LOD	0.62 (0.44 - 0.80)
Females, 6–11	2	530	51.70	—	<LOD	<LOD	0.25 (<LOD - 0.31)	0.74 (0.50 - 0.98)
Females, 12–19	2	498	57.03	—	<LOD	<LOD	0.23 (<LOD - 0.30)	0.83[E] (0.50 - 1.2)
Females, 20–39	2	770	72.47	—	<LOD	<LOD	<LOD[E] (<LOD - 0.22)	0.64[E] (0.40 - 0.88)
Females, 40–59	2	612	80.72	—	<LOD	<LOD	<LOD	0.47[E] (<LOD - 0.75)
Females, 60–79	2	581	85.03	—	<LOD	<LOD	<LOD	0.32 (0.21 - 0.44)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 8.16.3

Tungsten (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	6290	65.83	—	<LOD	<LOD	<LOD	0.69 (0.56 - 0.81)
3–5	2	572	47.03	—	<LOD	<LOD	0.69 (0.54 - 0.85)	2.0 (1.4 - 2.7)
6–11	2	1058	49.72	—	<LOD	<LOD	0.38 (0.32 - 0.45)	1.0 (0.66 - 1.4)
12–19	2	1038	53.37	—	<LOD	<LOD	0.24 (0.19 - 0.28)	0.62[E] (0.34 - 0.90)
20–39	2	1319	70.51	—	<LOD	<LOD	<LOD (<LOD - 0.26)	0.66[E] (0.35 - 0.97)
40–59	2	1223	78.82	—	<LOD	<LOD	<LOD	0.57 (0.40 - 0.75)
60–79	2	1080	83.15	—	<LOD	<LOD	<LOD	0.61 (0.49 - 0.73)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.16.4

Tungsten (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	3028	62.81	—	<LOD	<LOD	<LOD	0.58 (0.49 - 0.66)
Males, 6–11	2	530	47.55	—	<LOD	<LOD	0.44 (0.32 - 0.56)	1.2[E] (0.53 - 1.9)
Males, 12–19	2	541	49.91	—	<LOD	<LOD	0.24 (0.18 - 0.30)	0.58[E] (0.31 - 0.85)
Males, 20–39	2	550	67.64	—	<LOD	<LOD	<LOD (<LOD - 0.23)	0.50 (<LOD - 0.67)
Males, 40–59	2	615	76.42	—	<LOD	<LOD	<LOD	0.45 (0.37 - 0.52)
Males, 60–79	2	503	80.32	—	<LOD	<LOD	<LOD	0.52[E] (<LOD - 0.76)
Females, Total 3–79	2	3262	68.64	—	<LOD	<LOD	<LOD	0.82 (0.57 - 1.1)
Females, 6–11	2	528	51.89	—	<LOD	<LOD	0.35 (<LOD - 0.41)	0.85 (0.66 - 1.0)
Females, 12–19	2	497	57.14	—	<LOD	<LOD	0.23 (<LOD - 0.28)	0.74[E] (0.26 - 1.2)
Females, 20–39	2	769	72.56	—	<LOD	<LOD	<LOD (<LOD - 0.34)	0.78[E] (0.29 - 1.3)
Females, 40–59	2	608	81.25	—	<LOD	<LOD	<LOD	0.76[E] (<LOD - 1.2)
Females, 60–79	2	577	85.62	—	<LOD	<LOD	<LOD	0.63 (0.41 - 0.85)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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8.17 URANIUM

Pure uranium (CASRN 7440-61-1) is a silvery white, lustrous, weakly radioactive metal present at an average concentration in the Earth's crust of approximately 0.0002% (ATSDR, 2011). Uranium is not a stable element and undergoes radioactive decay, producing radioactive products as well as alpha and gamma radiation. Natural uranium is a mixture of three radioactive isotopes: uranium 238 (99.3%), uranium 235 (approximately 0.7%), and uranium 234 (0.005%) (WHO, 2003).

Uranium occurs naturally in variable, yet small, amounts in rock, soil, water, and air. It is naturally introduced into the atmosphere through the weathering of rock and soil (ATSDR, 2011). In addition to natural sources, uranium is released from anthropogenic sources such as uranium mining and milling, improper disposal of mill tailings, uranium processing, and burning of coal (ATSDR, 2011). Mining and milling operations can also alter the normal distribution of naturally occurring radioactive materials, possibly increasing the potential for human exposure. The use of depleted uranium ammunition during military training and combat operations can also lead to localized release of depleted uranium to soil at those locations (ATSDR, 2011).

Enriched uranium, containing a higher content of uranium 235 than natural uranium, is used primarily as a fuel in nuclear power reactors; it can also be a component of nuclear weapons (ATSDR, 2011). Depleted uranium is the by-product of the enrichment process and has a lower content of uranium 235 compared with natural uranium resulting in low radioactivity. Because of its high density, depleted uranium is used for military ammunition and armour-penetrating military ordnance (ATSDR, 2011). Civilian uses include aviation guidance devices and radiation shielding material for medical purposes. Historically, depleted uranium was also used in dentistry and to produce coloured ceramics and glasses (ATSDR, 2011).

Uranium intake is primarily through the ingestion of food, although drinking water and house dust can also be significant sources (CCME, 2007). The concentration of uranium in drinking water is highly variable and appears to depend on the source of the water (CCME, 2007).

Uranium compounds, such as uranium oxides, are not readily absorbed following oral ingestion and inhalation. Following ingestion, a small fraction (<5%) of ingested uranium rapidly appears in the bloodstream and is subsequently rapidly cleared. The vast majority of ingested uranium is excreted through the feces, and urine to a lesser extent, within a few days (ATSDR, 2011). Following inhalation, insoluble uranium compounds can remain in the lungs for years, whereas soluble forms enter the blood stream where they become concentrated in the bones and kidneys (CCME, 2007). The biological half-life in bone is approximately 11 days and in kidneys is 2 to 6 days (ATSDR, 2011). The most common test for uranium exposure is through urine because traces can remain for months after exposure, although urine tests are less accurate for low exposure levels (ATSDR, 2011). Other possible methods to determine if an individual has been exposed include testing blood and hair and measuring radiation levels within the body or on the skin.

Uranium can have health effects owing to both its chemical toxicity and the radiological toxicity of the radionuclides involved. Chemical toxicity effects are the same regardless of isotopic composition (Health Canada, 2008). Thus, the chemical toxicities of natural, depleted, and enriched uranium are identical. Based on human case reports and animal studies, the kidney is the organ primarily affected by the chemical toxicity of uranium following oral and inhalation exposure (ATSDR, 2011; Health Canada, 2008). Uranium chemical toxicity may also target the respiratory tract (inhalation only), neurological system, reproductive system, and the developing organism (ATSDR, 2011).

Because natural and depleted uranium are only weakly radioactive, health effects due to radioactivity, such as carcinogenicity, are generally observed only at much higher levels than those that can result in chemical toxicity (Health Canada, 2008). Health Canada has classified uranium as Group V, inadequate data for evaluation of carcinogenicity; the chemical carcinogenicity of uranium has been observed only from inhalation of highly insoluble or enriched uranium compounds and not from oral exposure (Health Canada, 2001). The International Agency for Research on Cancer determined that there was inadequate evidence in humans and limited evidence in laboratory animals for carcinogenicity of natural uranium (IARC, 2001). These evaluations consider only potential chemical carcinogenicity; radiation is considered carcinogenic.

A Canadian drinking water quality guideline has been developed that sets out the maximum acceptable concentration of uranium, considering both the toxicity and the cost of treating water to meet the guideline using currently available technologies (Health Canada, 2001; Health Canada, 2009a). Uranium is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009b). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply.

Uranium was measured in the whole blood and urine from all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented in blood as µg/L (Tables 8.17.1, 8.17.2, and 8.17.3) and in urine as both µg/L (Tables 8.17.4, 8.17.5, and 8.17.6) and µg/g creatinine (Tables 8.17.7, 8.17.8, and 8.17.9). Finding a measurable amount of uranium in blood or urine is an indicator of exposure to uranium and does not necessarily mean that an adverse health effect will occur.

Table 8.17.1

Uranium — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5304	93.02	—	<LOD	<LOD	<LOD	0.0051[E] (<LOD - 0.0070)
Total, 6–79	2	5575	98.80	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–79	1	2569	92.99	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.0067)
Males, Total 6–79	2	2687	98.70	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–79	1	2735	93.05	—	<LOD	<LOD	<LOD	0.0054[E] (<LOD - 0.0078)
Females, Total 6–79	2	2888	98.89	—	<LOD	<LOD	<LOD	<LOD

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.17.2

Uranium — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6070	98.80	—	<LOD	<LOD	<LOD	<LOD
3–5[b]	1							
3–5	2	495	98.79	—	<LOD	<LOD	<LOD	<LOD
6–11	1	905	92.71	—	<LOD	<LOD	<LOD	0.0052[E] (<LOD - 0.0078)
6–11	2	961	97.92	—	<LOD	<LOD	<LOD	<LOD
12–19	1	941	93.94	—	<LOD	<LOD	<LOD	0.0051[E] (<LOD - 0.0071)
12–19	2	997	99.10	—	<LOD	<LOD	<LOD	<LOD
20–39	1	1162	91.14	—	<LOD	<LOD	<LOD	0.0056 (<LOD - 0.0076)
20–39	2	1313	99.16	—	<LOD	<LOD	<LOD	<LOD
40–59	1	1217	92.77	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.0068)
40–59	2	1222	98.28	—	<LOD	<LOD	<LOD	<LOD
60–79	1	1079	94.81	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.0069)
60–79	2	1082	99.45	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.17.3

Uranium — Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2940	98.67	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	1	457	93.65	—	<LOD	<LOD	<LOD	0.0051^{E} (<LOD - 0.0072)
Males, 6–11	2	488	97.75	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	1	489	93.87	—	<LOD	<LOD	<LOD	F
Males, 12–19	2	523	99.43	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	1	511	91.59	—	<LOD	<LOD	<LOD	<LOD^{E} (<LOD - 0.0069)
Males, 20–39	2	552	98.91	—	<LOD	<LOD	<LOD	<LOD
Males, 40–59	1	575	91.48	—	<LOD	<LOD	<LOD	<LOD^{E} (<LOD - 0.0081)
Males, 40–59	2	617	97.73	—	<LOD	<LOD	<LOD	<LOD
Males, 60–79	1	537	94.60	—	<LOD	<LOD	<LOD	F
Males, 60–79	2	507	99.80	—	<LOD	<LOD	<LOD	<LOD
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3130	98.91	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	1	448	91.74	—	<LOD	<LOD	<LOD	0.0054^{E} (<LOD - 0.0087)
Females, 6–11	2	473	98.10	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	1	452	94.03	—	<LOD	<LOD	<LOD	0.0059^{E} (<LOD - 0.0089)
Females, 12–19	2	474	98.73	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	1	651	90.78	—	<LOD	<LOD	<LOD	0.0066^{E} (<LOD - 0.0099)
Females, 20–39	2	761	99.34	—	<LOD	<LOD	<LOD	<LOD
Females, 40–59	1	642	93.93	—	<LOD	<LOD	<LOD	F
Females, 40–59	2	605	98.84	—	<LOD	<LOD	<LOD	<LOD
Females, 60–79	1	542	95.02	—	<LOD	<LOD	<LOD	0.0050^{E} (<LOD - 0.0080)
Females, 60–79	2	575	99.13	—	<LOD	<LOD	<LOD	<LOD

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.17.4

Uranium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5491	87.05	—	<LOD	<LOD	<LOD	0.015[E] (<LOD - 0.021)
Total, 6–79	2	5738	83.88	—	<LOD	<LOD	<LOD	0.020 (0.018 - 0.023)
Males, Total 6–79	1	2662	85.88	—	<LOD	<LOD	<LOD	0.016 (0.010 - 0.022)
Males, Total 6–79	2	2746	83.07	—	<LOD	<LOD	<LOD	0.020 (0.018 - 0.023)
Females, Total 6–79	1	2829	88.16	—	<LOD	<LOD	<LOD	0.013[E] (<LOD - 0.019)
Females, Total 6–79	2	2992	84.63	—	<LOD	<LOD	<LOD	0.021 (0.015 - 0.027)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.17.5

Uranium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6311	84.49	—	<LOD	<LOD	<LOD	0.020 (0.017 - 0.023)
3–5[b]	1							
3–5	2	573	90.58	—	<LOD	<LOD	<LOD	0.012[E] (<LOD - 0.019)
6–11	1	1034	89.36	—	<LOD	<LOD	<LOD	0.012[E] (<LOD - 0.018)
6–11	2	1062	86.44	—	<LOD	<LOD	<LOD	0.014 (0.011 - 0.017)
12–19	1	983	83.11	—	<LOD	<LOD	<LOD	0.019 (0.013 - 0.025)
12–19	2	1041	76.56	—	<LOD	<LOD	<LOD	0.022 (0.020 - 0.024)
20–39	1	1169	87.43	—	<LOD	<LOD	<LOD	F
20–39	2	1321	85.16	—	<LOD	<LOD	<LOD	0.021 (0.018 - 0.025)
40–59	1	1223	86.26	—	<LOD	<LOD	<LOD	0.014 (<LOD - 0.019)
40–59	2	1228	85.59	—	<LOD	<LOD	<LOD	0.017 (0.013 - 0.022)
60–79	1	1082	88.91	—	<LOD	<LOD	<LOD	0.013[E] (<LOD - 0.019)
60–79	2	1086	84.90	—	<LOD	<LOD	<LOD	0.022[E] (0.014 - 0.030)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.17.6

Uranium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	83.70	—	<LOD	<LOD	<LOD	0.020 (0.018 - 0.023)
Males, 6–11	1	524	89.50	—	<LOD	<LOD	<LOD	0.014[E] (<LOD - 0.023)
Males, 6–11	2	532	87.22	—	<LOD	<LOD	<LOD	0.014 (<LOD - 0.018)
Males, 12–19	1	505	80.20	—	<LOD	<LOD	<LOD	0.019[E] (<LOD - 0.030)
Males, 12–19	2	542	75.83	—	<LOD	<LOD	<LOD	0.021 (0.017 - 0.026)
Males, 20–39	1	514	87.35	—	<LOD	<LOD	<LOD	F
Males, 20–39	2	551	83.30	—	<LOD	<LOD	<LOD	0.021[E] (0.013 - 0.030)
Males, 40–59	1	578	83.39	—	<LOD	<LOD	<LOD	0.016 (0.011 - 0.021)
Males, 40–59	2	616	83.28	—	<LOD	<LOD	<LOD	0.018 (0.013 - 0.023)
Males, 60–79	1	541	88.91	—	<LOD	<LOD	<LOD	0.014[E] (<LOD - 0.020)
Males, 60–79	2	505	85.94	—	<LOD	<LOD	<LOD	0.022[E] (<LOD - 0.035)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	85.22	—	<LOD	<LOD	<LOD	0.020 (0.014 - 0.027)
Females, 6–11	1	510	89.22	—	<LOD	<LOD	<LOD	0.010[E] (<LOD - 0.014)
Females, 6–11	2	530	85.66	—	<LOD	<LOD	<LOD	0.014 (<LOD - 0.019)
Females, 12–19	1	478	86.19	—	<LOD	<LOD	<LOD	0.018 (0.013 - 0.023)
Females, 12–19	2	499	77.35	—	<LOD	<LOD	<LOD	0.023 (0.015 - 0.030)
Females, 20–39	1	655	87.48	—	<LOD	<LOD	<LOD	F
Females, 20–39	2	770	86.49	—	<LOD	<LOD	<LOD	0.022[E] (0.012 - 0.032)
Females, 40–59	1	645	88.84	—	<LOD	<LOD	<LOD	0.012[E] (<LOD - 0.018)
Females, 40–59	2	612	87.91	—	<LOD	<LOD	<LOD	0.016[E] (<LOD - 0.024)
Females, 60–79	1	541	88.91	—	<LOD	<LOD	<LOD	0.011[E] (<LOD - 0.018)
Females, 60–79	2	581	83.99	—	<LOD	<LOD	<LOD	0.021[E] (0.013 - 0.029)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.17.7

Uranium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5478	87.26	—	<LOD	<LOD	<LOD	0.030 (<LOD - 0.034)
Total, 6–79	2	5719	84.16	—	<LOD	<LOD	<LOD	0.024 (0.021 - 0.028)
Males, Total 6–79	1	2653	86.17	—	<LOD	<LOD	<LOD	0.024 (0.019 - 0.029)
Males, Total 6–79	2	2739	83.28	—	<LOD	<LOD	<LOD	0.020 (0.014 - 0.026)
Females, Total 6–79	1	2825	88.28	—	<LOD	<LOD	<LOD	0.035 (<LOD - 0.041)
Females, Total 6–79	2	2980	84.97	—	<LOD	<LOD	<LOD	0.027 (0.023 - 0.031)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.17.8

Uranium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6291	84.76	—	<LOD	<LOD	<LOD	0.025 (0.021 - 0.028)
3–5[b]	1							
3–5	2	572	90.73	—	<LOD	<LOD	<LOD	0.030[E] (<LOD - 0.044)
6–11	1	1031	89.62	—	<LOD	<LOD	<LOD	0.038 (<LOD - 0.049)
6–11	2	1058	86.77	—	<LOD	<LOD	<LOD	0.019 (0.015 - 0.023)
12–19	1	982	83.20	—	<LOD	<LOD	<LOD	0.022 (0.016 - 0.028)
12–19	2	1039	76.71	—	<LOD	<LOD	<LOD	0.018[E] (0.011 - 0.026)
20–39	1	1165	87.73	—	<LOD	<LOD	<LOD	0.031 (<LOD - 0.039)
20–39	2	1319	85.29	—	<LOD	<LOD	<LOD	0.021[E] (0.0075 - 0.034)
40–59	1	1218	86.62	—	<LOD	<LOD	<LOD	0.030 (<LOD - 0.034)
40–59	2	1223	85.94	—	<LOD	<LOD	<LOD	0.024 (0.021 - 0.028)
60–79	1	1082	88.91	—	<LOD	<LOD	<LOD	0.030 (<LOD - 0.036)
60–79	2	1080	85.37	—	<LOD	<LOD	<LOD	0.029 (0.022 - 0.036)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.17.9

Uranium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	83.92	—	<LOD	<LOD	<LOD	0.020 (0.013 - 0.027)
Males, 6–11	1	522	89.85	—	<LOD	<LOD	<LOD	0.039^{E} (<LOD - 0.057)
Males, 6–11	2	530	87.55	—	<LOD	<LOD	<LOD	0.017^{E} (<LOD - 0.023)
Males, 12–19	1	504	80.36	—	<LOD	<LOD	<LOD	0.020 (<LOD - 0.027)
Males, 12–19	2	541	75.97	—	<LOD	<LOD	<LOD	0.013^{E} (0.0073 - 0.019)
Males, 20–39	1	512	87.70	—	<LOD	<LOD	<LOD	0.025^{E} (<LOD - 0.036)
Males, 20–39	2	550	83.45	—	<LOD	<LOD	<LOD	F
Males, 40–59	1	574	83.97	—	<LOD	<LOD	<LOD	0.023 (0.017 - 0.028)
Males, 40–59	2	615	83.41	—	<LOD	<LOD	<LOD	0.020 (0.015 - 0.026)
Males, 60–79	1	541	88.91	—	<LOD	<LOD	<LOD	0.019 (<LOD - 0.023)
Males, 60–79	2	503	86.28	—	<LOD	<LOD	<LOD	0.024^{E} (<LOD - 0.037)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	85.53	—	<LOD	<LOD	<LOD	0.027 (0.024 - 0.031)
Females, 6–11	1	509	89.39	—	<LOD	<LOD	<LOD	0.035 (<LOD - 0.046)
Females, 6–11	2	528	85.98	—	<LOD	<LOD	<LOD	0.021 (<LOD - 0.024)
Females, 12–19	1	478	86.19	—	<LOD	<LOD	<LOD	0.025^{E} (0.015 - 0.034)
Females, 12–19	2	498	77.51	—	<LOD	<LOD	<LOD	0.026^{E} (0.015 - 0.037)
Females, 20–39	1	653	87.75	—	<LOD	<LOD	<LOD	0.033 (<LOD - 0.041)
Females, 20–39	2	769	86.61	—	<LOD	<LOD	<LOD	0.022^{E} (0.012 - 0.032)
Females, 40–59	1	644	88.98	—	<LOD	<LOD	<LOD	0.039 (<LOD - 0.051)
Females, 40–59	2	608	88.49	—	<LOD	<LOD	<LOD	0.026 (<LOD - 0.030)
Females, 60–79	1	541	88.91	—	<LOD	<LOD	<LOD	0.040 (<LOD - 0.050)
Females, 60–79	2	577	84.58	—	<LOD	<LOD	<LOD	0.032 (0.028 - 0.037)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

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8.18 VANADIUM

Vanadium (CASRN 7440-62-2) is a naturally occurring element present in the the Earth's crust at an average of approximately 0.01%. It is present in iron ores, phosphate rock, and crude oil deposits (ATSDR, 2009). Vanadium is usually found combined with other elements and can exist in six different oxidation states, acting as either a metal or non-metal.

Vanadium is generally associated with organic matter; it can be found in crude oil and various refined petroleum products, particularly heavy fuel oil. Lesser natural sources of vanadium include erosion and weathering of rock-bearing minerals, sea spray, and volcanic emissions (ATSDR, 2009). Anthropogenic sources of vanadium include petroleum refineries, electrical power generation plants, and the pulp and paper industry through the burning of fossil and wood fuels (Environment Canada & Health Canada, 2010).

Vanadium is used mainly as an alloy additive in the production of various steels to increase strength, hardness, wear resistance, and ductility. Some vanadium is used to produce ferrovanadium alloys for aircraft engines and nonferrous titanium alloys. In addition, vanadium is used in the manufacture of phthalic anhydride and sulphuric acid, as a catalyst in processes such as petroleum cracking, and in the production of pesticides, dyes, inks, and pigments (Vanadium Investing News, 2011). The vanadium redox-flow battery is an emerging technology that may be used to store electricity generated by large-scale wind and solar farms (Vanadium Investing News, 2011). Vanadium may also be found in various commercial nutritional supplements and multivitamins (Health Canada, 2007).

The main source of vanadium for the general population is through food, although exposure can also come from air, drinking water, soil, and household dust (ATSDR, 2009). When it is used as a supplement, this use can account for much of the exposure to vanadium (Pennington & Jones, 1987).

Vanadium can be absorbed following inhalation, oral, or dermal exposure, with dermal absorption being less efficient than inhalation or oral absorption. Long-term distribution of vanadium in the body is independent of the route of exposure, with bones being the main reservoir. Ingested vanadium is mainly excreted through the feces; the kidneys are the main route for elimination of absorbed vanadium (ACGIH, 2001). Tissue elimination occurs with half-lives ranging from 3 to 15 days (ATSDR, 2009). Absorption of ingested vanadium is less than 5%, thus most ingested vanadium is found in the feces (IOM, 2001). Urinary vanadium can be a biomarker of exposure to absorbed vanadium and vanadium-related compounds, such as vanadium oxide (ATSDR, 2009). However, because the relationship between external exposure and urine concentrations is variable, urinary vanadium provides only a qualitative indication of external exposure (ILO, 1998).

Vanadium is believed to have beneficial effects at low doses; however, its role in the body remains unclear (IOM, 2001). The Institute of Medicine (IOM) has concluded that data are insufficient to establish recommended dietary allowances (IOM, 2001). There is evidence in humans of mild gastrointestinal effects and hematological effects, such as anemia, following ingestion of vanadium compounds (ATSDR, 2009). Renal toxicity has been observed in animals following ingestion of vanadium compounds, but these effects have not been seen in humans (IOM, 2001). Acute inhalation exposure to vanadium, particularly vanadium pentoxide, has been associated with respiratory irritation (ATSDR, 2009).

The International Agency for Research on Cancer recently evaluated the carcinogenicity of vanadium pentoxide and has classified it as Group 2B, a possible human carcinogen, based on inadequate human data but sufficient evidence of respiratory cancers in rodent inhalation studies (IARC, 2006).

As part of the Chemicals Management Plan under the *Canadian Environmental Protection Act, 1999* (CEPA 1999), vanadium pentoxide was identified as a priority substance (Canada, 1999; Canada, 2011). The final screening assessment was published in September 2010 and concluded on the basis of carcinogenicity that there may be a probability of harm at any level of exposure (Environment Canada & Health Canada, 2010). Applying a precautionary approach, it was concluded that vanadium pentoxide may be entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health (Environment Canada & Health Canada, 2010). In 2010, vanadium pentoxide was listed as a toxic substance on Schedule 1 of the CEPA 1999 (Canada, 2010a). To manage the risks posed by vanadium pentoxide, existing programs will be used to reduce particulate emissions from combustion of certain fossil fuels (Canada, 2010b).

Health Canada has adopted tolerable upper intake levels for vanadium developed by the Institute of Medicine based upon renal toxicity as the critical adverse effect (Health Canada, 2007; IOM, 2001). There is currently no Canadian guideline for vanadium in drinking water (Health Canada, 2012).

Vanadium was measured in the urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented as both µg/L (Tables 8.18.1, 8.18.2, and 8.18.3) and µg/g creatinine (Tables 8.18.4, 8.18.5, and 8.18.6). Finding a measurable amount of vanadium in urine is an indicator of exposure to vanadium and does not necessarily mean that an adverse health effect will occur.

Table 8.18.1

Vanadium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5492	90.37	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.12)
Total, 6–79	2	5738	91.50	—	<LOD	<LOD	<LOD	0.13 (0.10 - 0.15)
Males, Total 6–79	1	2662	88.32	—	<LOD	<LOD	<LOD	0.14 (0.11 - 0.17)
Males, Total 6–79	2	2746	89.99	—	<LOD	<LOD	<LOD	0.15 (0.11 - 0.19)
Females, Total 6–79	1	2830	92.30	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–79	2	2992	92.88	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.13)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.18.2

Vanadium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6311	91.92	—	<LOD	<LOD	<LOD	0.13 (<LOD - 0.15)
3–5[b]	1							
3–5	2	573	96.16	—	<LOD	<LOD	<LOD	<LOD
6–11	1	1034	94.68	—	<LOD	<LOD	<LOD	<LOD
6–11	2	1062	96.61	—	<LOD	<LOD	<LOD	<LOD
12–19	1	983	92.98	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.13)
12–19	2	1041	92.12	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.14)
20–39	1	1169	89.56	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.13)
20–39	2	1321	90.76	—	<LOD	<LOD	<LOD	0.13 (<LOD - 0.17)
40–59	1	1223	88.72	—	<LOD	<LOD	<LOD	0.11 (<LOD - 0.15)
40–59	2	1228	88.93	—	<LOD	<LOD	<LOD	0.14[E] (<LOD - 0.21)
60–79	1	1083	86.61	—	<LOD	<LOD	<LOD	0.12[E] (<LOD - 0.17)
60–79	2	1086	89.69	—	<LOD	<LOD	<LOD	0.13[E] (<LOD - 0.18)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.18.3

Vanadium — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	90.48	—	<LOD	<LOD	<LOD	0.15 (0.11 - 0.19)
Males, 6–11	1	524	95.04	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	532	96.62	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	1	505	92.87	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.13)
Males, 12–19	2	542	91.88	—	<LOD	<LOD	<LOD	F
Males, 20–39	1	514	87.74	—	<LOD	<LOD	<LOD	0.12[E] (<LOD - 0.16)
Males, 20–39	2	551	85.48	—	<LOD	<LOD	<LOD	0.16 (0.11 - 0.22)
Males, 40–59	1	578	84.60	—	<LOD	<LOD	<LOD	0.19[E] (0.11 - 0.26)
Males, 40–59	2	616	87.66	—	<LOD	<LOD	<LOD	F
Males, 60–79	1	541	82.07	—	<LOD	<LOD	<LOD	0.18 (0.12 - 0.25)
Males, 60–79	2	505	88.71	—	<LOD	<LOD	<LOD	0.14[E] (<LOD - 0.20)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	93.25	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.13)
Females, 6–11	1	510	94.31	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	530	96.60	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	1	478	93.10	—	<LOD	<LOD	<LOD	0.11[E] (<LOD - 0.16)
Females, 12–19	2	499	92.38	—	<LOD	<LOD	<LOD	0.12[E] (<LOD - 0.18)
Females, 20–39	1	655	90.99	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.12)
Females, 20–39	2	770	94.55	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 0.14)
Females, 40–59	1	645	92.40	—	<LOD	<LOD	<LOD	<LOD
Females, 40–59	2	612	90.20	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.13)
Females, 60–79	1	542	91.14	—	<LOD	<LOD	<LOD	<LOD
Females, 60–79	2	581	90.53	—	<LOD	<LOD	<LOD	0.12[E] (<LOD - 0.17)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 8.18.4

Vanadium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5479	90.58	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.33)
Total, 6–79	2	5719	91.80	—	<LOD	<LOD	<LOD	0.24 (0.21 - 0.26)
Males, Total 6–79	1	2653	88.62	—	<LOD	<LOD	<LOD	0.25 (0.20 - 0.30)
Males, Total 6–79	2	2739	90.22	—	<LOD	<LOD	<LOD	0.18 (0.14 - 0.22)
Females, Total 6–79	1	2826	92.43	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–79	2	2980	93.26	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.31)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.18.5

Vanadium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6291	92.21	—	<LOD	<LOD	<LOD	0.24 (<LOD - 0.26)
3–5[b]	1							
3–5	2	572	96.33	—	<LOD	<LOD	<LOD	<LOD
6–11	1	1031	94.96	—	<LOD	<LOD	<LOD	<LOD
6–11	2	1058	96.98	—	<LOD	<LOD	<LOD	<LOD
12–19	1	982	93.08	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.23)
12–19	2	1039	92.30	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.20)
20–39	1	1165	89.87	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.37)
20–39	2	1319	90.90	—	<LOD	<LOD	<LOD	0.21[E] (<LOD - 0.30)
40–59	1	1218	89.08	—	<LOD	<LOD	<LOD	0.30 (<LOD - 0.34)
40–59	2	1223	89.29	—	<LOD	<LOD	<LOD	0.24 (<LOD - 0.27)
60–79	1	1083	86.61	—	<LOD	<LOD	<LOD	0.30 (<LOD - 0.35)
60–79	2	1080	90.19	—	<LOD	<LOD	<LOD	0.30 (<LOD - 0.34)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.18.6

Vanadium (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	90.72	—	<LOD	<LOD	<LOD	0.18 (0.14 - 0.22)
Males, 6–11	1	522	95.40	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	530	96.98	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	1	504	93.06	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.24)
Males, 12–19	2	541	92.05	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.16)
Males, 20–39	1	512	88.09	—	<LOD	<LOD	<LOD	0.25[E] (<LOD - 0.36)
Males, 20–39	2	550	85.64	—	<LOD	<LOD	<LOD	F
Males, 40–59	1	574	85.19	—	<LOD	<LOD	<LOD	0.26 (0.21 - 0.31)
Males, 40–59	2	615	87.80	—	<LOD	<LOD	<LOD	0.21 (<LOD - 0.27)
Males, 60–79	1	541	82.07	—	<LOD	<LOD	<LOD	0.21 (0.17 - 0.25)
Males, 60–79	2	503	89.07	—	<LOD	<LOD	<LOD	0.20 (<LOD - 0.25)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	93.59	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.31)
Females, 6–11	1	509	94.50	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	528	96.97	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	1	478	93.10	—	<LOD	<LOD	<LOD	0.21[E] (<LOD - 0.28)
Females, 12–19	2	498	92.57	—	<LOD	<LOD	<LOD	0.22[E] (<LOD - 0.32)
Females, 20–39	1	653	91.27	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.44)
Females, 20–39	2	769	94.67	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.34)
Females, 40–59	1	644	92.55	—	<LOD	<LOD	<LOD	<LOD
Females, 40–59	2	608	90.79	—	<LOD	<LOD	<LOD	<LOD (<LOD - 0.33)
Females, 60–79	1	542	91.14	—	<LOD	<LOD	<LOD	<LOD
Females, 60–79	2	577	91.16	—	<LOD	<LOD	<LOD	0.33 (<LOD - 0.38)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

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8.19 ZINC

Zinc (CASRN 7440-66-6), one of the more common naturally occurring elements, is present in the Earth's crust at an average of approximately 0.0075% (Emsley, 2001). It is a lustrous, bluish white, relatively soft metal in its pure state. Zinc is a base metal that exists naturally in a divalent oxidation state in various inorganic and organic compounds. The most common zinc ore is sphalerite that often exists with the sulphides of other metallic elements (e.g. lead, copper, cadmium, and iron) (EPA, 1976). Zinc is also found as calamine in carbonate sediments; other forms of zinc are usually products of the oxidation of sphalerite (EPA, 1976; Hem, 1970). Zinc is an essential trace element required for the maintenance of good health in humans.

Natural emissions of zinc and its compounds to air are due mainly to windborne soil particles, volcanic emissions, and forest fires (ATSDR, 2005). The major anthropogenic sources of zinc include electroplating, smelting and ore processing, drainage from both active and inactive mining operations, coal and fuel combustion, waste disposal and incineration, iron and steel production, municipal effluents, and the use of zinc-containing fertilizers (ATSDR, 2005).

Zinc is used mainly for galvanizing other metal products, such as iron and steel, to prevent corrosion. Other principal uses include the production of alloys, such as brass and bronze, and the manufacture of dry-cell batteries. Zinc is also used in paints, preservatives, dyes, pesticides, and various cosmetic and pharmaceutical products; in the manufacture of rayons, yarns, inks, matches, tires, and other rubber products; for cementing metals in metallurgical processing; and in ornamental work (CCME, 1999; Health Canada, 1987). Zinc compounds can also be found in products such as vitamin or mineral supplements, sunscreens, deodorants, and anti-dandruff shampoos.

The general population is primarily exposed to zinc at low levels through the ingestion of food. Increased exposure may occur from drinking water from pipes and fittings leaching zinc. Following ingestion, zinc is absorbed via the gastrointestinal tract and then transported to various tissues and organs. In persons with adequate nutritional levels, between 20% and 30% of dietary zinc is absorbed; however, enhanced absorption is known to occur under conditions of zinc deficiency (ATSDR, 2005). Over 85% of the total body zinc is found in skeletal muscle and bone (IOM, 2001). The primary route of excretion from the body is via the gastrointestinal tract; this excretion includes unabsorbed dietary zinc, a small amount from sloughing of intestinal epithelial cells, and zinc from biliary and pancreatic origin. Under normal circumstances, a small amount of zinc may be lost daily in perspiration and in urine (Prasad, 1983). Concentrations of zinc in serum and urine are believed to increase after exposure. Serum zinc levels are commonly used as indicators of population zinc status (Hess et al., 2007). Hair and nail samples have also been suggested to have potential value for monitoring longer-term exposure (ATSDR, 2005).

As an essential trace element, zinc is required as a component of many metalloenzymes and other substances in the body (Health Canada, 1987). It aids in connective tissue formation, the maintenance of healthy skin, immune system functioning, and the metabolism of carbohydrates, fats, and proteins (CCME, 1999; Health Canada, 1987; Health Canada, 2007). Zinc deficiency may lead to dermatitis, anorexia, reduced growth, poor healing of wounds, reduced reproductive ability, reduced mental function, and impairment of the immune system (ATSDR, 2005). Insufficient zinc intake may also have an impact on the carcinogenicity of other chemicals (ATSDR, 2005). On account of its essentiality, Health Canada has established recommended dietary allowances for zinc (Health Canada, 2010; IOM, 2001).

Acute zinc toxicity is usually the result of taking excessive amounts of vitamin or mineral supplements or drinking acidic beverages stored for long periods of time in galvanized containers (WHO, 2003). Acute exposure to large doses of zinc can cause stomach cramps, nausea, and vomiting (ATSDR, 2005). Ingesting high levels of zinc and chronic low-dose exposure can inhibit absorption of copper into the blood stream and cause copper deficiency (ATSDR, 2005; EPA, 2005a; WHO, 2003). Effects of inhaled zinc are generally limited to the respiratory tract and vary depending on the specific chemical composition (ATSDR, 2005). Data demonstrating an increase in cancer incidence following long-term exposure to zinc compounds are insufficient, and zinc has not been classified with respect to its carcinogenicity by the International Agency for Research on Cancer. Based on this lack of information, the United States Environmental Protection Agency has determined that zinc is not classifiable as to its human carcinogenicity (EPA, 2005b).

Health Canada has established maximum recommended levels for zinc in dietary supplement formulations in Canada (Health Canada, 2007). Tolerable upper intake levels for zinc, which account for its potential toxicity, have been developed by the Institute of Medicine and adopted by Health Canada (Health Canada, 2010; IOM, 2001). Health Canada has also developed a Canadian drinking water quality guideline that sets out the aesthetic objective for zinc based upon taste (Health Canada, 1987). Although a health-based guideline has not been established, the aesthetic guideline is deemed protective of adverse health effects. Zinc is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (Health Canada, 2009). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply.

In a study carried out in British Columbia to assess the levels of trace elements in 61 non-smoking adults aged 30 to 65 years, the geometric mean concentration and 95th percentile of zinc in urine were 285.43 µg/g creatinine and 607.83 µg/g creatinine, respectively (Clark et al., 2007).

Zinc was measured in the whole blood and urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented in blood as mg/L (Tables 8.19.1, 8.19.2, and 8.19.3) and in urine as both µg/L and µg/g creatinine (Tables 8.19.4, 8.19.5, 8.19.6, 8.19.7, 8.19.8, and 8.19.9). Finding a measurable amount of zinc in blood or urine is an indicator of exposure to zinc and does not necessarily mean that an adverse health effect will occur. Because zinc is an essential nutrient, its presence in biological fluids is expected.

Table 8.19.1

Zinc — Geometric means and selected percentiles of whole blood concentrations (mg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5319	0	6.4 (6.3 - 6.5)	5.2 (5.1 - 5.3)	6.4 (6.3 - 6.4)	7.0 (6.9 - 7.1)	7.9 (7.7 - 8.0)
Total, 6–79	2	5575	0	6.0 (5.9 - 6.1)	4.9 (4.9 - 5.0)	6.0 (5.9 - 6.1)	6.5 (6.5 - 6.5)	7.3 (7.1 - 7.6)
Males, Total 6–79	1	2576	0	6.6 (6.5 - 6.7)	5.3 (5.3 - 5.4)	6.7 (6.5 - 6.8)	7.3 (7.2 - 7.4)	8.1 (7.9 - 8.3)
Males, Total 6–79	2	2687	0	6.2 (6.1 - 6.3)	5.1 (4.9 - 5.2)	6.3 (6.2 - 6.4)	6.6 (6.5 - 6.7)	7.7 (7.5 - 8.0)
Females, Total 6–79	1	2743	0	6.1 (6.0 - 6.2)	5.1 (5.0 - 5.2)	6.1 (6.0 - 6.2)	6.7 (6.6 - 6.8)	7.5 (7.4 - 7.7)
Females, Total 6–79	2	2888	0	5.7 (5.7 - 5.8)	4.8 (4.8 - 4.9)	5.7 (5.7 - 5.8)	6.2 (6.2 - 6.3)	6.8 (6.5 - 7.1)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.19.2

Zinc — Geometric means and selected percentiles of whole blood concentrations (mg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6070	0	5.9 (5.9 - 6.0)	4.9 (4.8 - 4.9)	5.9 (5.9 - 6.0)	6.5 (6.5 - 6.5)	7.3 (7.1 - 7.5)
3–5[b]	1							
3–5	2	495	0	4.6 (4.5 - 4.7)	3.7 (3.5 - 3.9)	4.6 (4.5 - 4.7)	5.0 (4.9 - 5.1)	5.6 (5.4 - 5.9)
6–11	1	910	0	5.2 (5.1 - 5.4)	4.3 (4.2 - 4.5)	5.2 (5.1 - 5.3)	5.7 (5.6 - 5.8)	6.5 (6.3 - 6.6)
6–11	2	961	0	4.9 (4.9 - 5.0)	4.1 (3.9 - 4.2)	4.9 (4.9 - 5.0)	5.4 (5.3 - 5.5)	6.1 (6.0 - 6.3)
12–19	1	945	0	6.0 (5.9 - 6.1)	4.9 (4.7 - 5.1)	6.0 (5.8 - 6.1)	6.5 (6.4 - 6.6)	7.4 (7.2 - 7.6)
12–19	2	997	0	5.6 (5.5 - 5.7)	4.6 (4.5 - 4.7)	5.5 (5.5 - 5.6)	6.2 (6.0 - 6.4)	7.0 (6.7 - 7.2)
20–39	1	1165	0	6.4 (6.3 - 6.5)	5.3 (5.1 - 5.4)	6.4 (6.3 - 6.5)	7.0 (6.9 - 7.1)	7.8 (7.6 - 8.0)
20–39	2	1313	0	6.1 (6.0 - 6.2)	5.2 (5.0 - 5.3)	6.0 (5.9 - 6.2)	6.5 (6.5 - 6.5)	7.3 (7.0 - 7.7)
40–59	1	1220	0	6.5 (6.4 - 6.6)	5.5 (5.3 - 5.6)	6.5 (6.3 - 6.6)	7.1 (7.0 - 7.2)	7.9 (7.7 - 8.2)
40–59	2	1222	0	6.1 (6.0 - 6.3)	5.1 (5.0 - 5.3)	6.1 (6.0 - 6.2)	6.5 (6.5 - 6.5)	7.5 (7.2 - 7.8)
60–79	1	1079	0	6.7 (6.6 - 6.8)	5.6 (5.4 - 5.8)	6.7 (6.5 - 6.8)	7.3 (7.1 - 7.4)	8.1 (7.9 - 8.2)
60–79	2	1082	0	6.2 (6.1 - 6.3)	5.2 (5.1 - 5.3)	6.2 (6.0 - 6.3)	6.5 (6.5 - 6.5)	7.4 (7.2 - 7.5)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.19.3

Zinc — Geometric means and selected percentiles of whole blood concentrations (mg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2940	0	6.2 (6.1 - 6.3)	5.0 (4.9 - 5.0)	6.2 (6.1 - 6.3)	6.6 (6.5 - 6.7)	7.7 (7.4 - 7.9)
Males, 6–11	1	459	0	5.2 (5.0 - 5.3)	4.3 (4.2 - 4.5)	5.1 (4.9 - 5.3)	5.6 (5.5 - 5.7)	6.4 (6.1 - 6.6)
Males, 6–11	2	488	0	4.9 (4.8 - 5.0)	4.0 (3.6 - 4.4)	4.9 (4.8 - 5.0)	5.4 (5.3 - 5.5)	6.1 (6.0 - 6.2)
Males, 12–19	1	489	0	6.1 (5.9 - 6.2)	4.8 (4.5 - 5.1)	6.1 (5.8 - 6.3)	6.8 (6.6 - 7.0)	7.8 (7.4 - 8.3)
Males, 12–19	2	523	0	5.8 (5.6 - 5.9)	4.5 (4.3 - 4.7)	5.8 (5.6 - 6.0)	6.5 (6.3 - 6.6)	7.3 (6.9 - 7.7)
Males, 20–39	1	514	0	6.7 (6.6 - 6.9)	5.6 (5.3 - 6.0)	6.7 (6.5 - 6.9)	7.3 (7.2 - 7.5)	8.0 (7.7 - 8.3)
Males, 20–39	2	552	0	6.4 (6.2 - 6.6)	5.4 (5.1 - 5.7)	6.4 (6.2 - 6.5)	6.7 (6.5 - 6.8)	7.8 (7.4 - 8.3)
Males, 40–59	1	577	0	6.9 (6.7 - 7.0)	5.9 (5.7 - 6.1)	6.8 (6.7 - 7.0)	7.4 (7.3 - 7.6)	8.2 (7.9 - 8.6)
Males, 40–59	2	617	0	6.4 (6.3 - 6.6)	5.5 (5.3 - 5.7)	6.4 (6.2 - 6.5)	6.7 (6.5 - 6.9)	7.8 (7.4 - 8.2)
Males, 60–79	1	537	0	6.9 (6.8 - 7.1)	5.9 (5.8 - 6.0)	6.9 (6.7 - 7.1)	7.5 (7.4 - 7.6)	8.2 (8.0 - 8.4)
Males, 60–79	2	507	0	6.5 (6.4 - 6.6)	5.5 (5.3 - 5.6)	6.5 (6.4 - 6.5)	6.8 (6.6 - 6.9)	7.7 (7.5 - 7.9)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3130	0	5.7 (5.6 - 5.8)	4.8 (4.7 - 4.8)	5.7 (5.7 - 5.8)	6.2 (6.1 - 6.3)	6.8 (6.5 - 7.1)
Females, 6–11	1	451	0	5.3 (5.2 - 5.4)	4.4 (4.1 - 4.6)	5.3 (5.2 - 5.4)	5.8 (5.6 - 5.9)	6.5 (6.4 - 6.7)
Females, 6–11	2	473	0	5.0 (4.9 - 5.1)	4.1 (4.0 - 4.2)	4.9 (4.8 - 5.1)	5.4 (5.3 - 5.6)	6.2 (5.9 - 6.5)
Females, 12–19	1	456	0	5.9 (5.7 - 6.0)	5.0 (4.8 - 5.2)	5.8 (5.7 - 6.0)	6.3 (6.2 - 6.5)	7.0 (6.8 - 7.2)
Females, 12–19	2	474	0	5.5 (5.4 - 5.6)	4.7 (4.5 - 4.8)	5.4 (5.4 - 5.5)	5.9 (5.7 - 6.1)	6.5 (6.5 - 6.6)
Females, 20–39	1	651	0	6.1 (6.0 - 6.3)	5.1 (4.9 - 5.3)	6.1 (5.9 - 6.3)	6.6 (6.5 - 6.8)	7.5 (7.0 - 7.9)
Females, 20–39	2	761	0	5.8 (5.7 - 5.9)	5.0 (4.9 - 5.2)	5.8 (5.7 - 5.9)	6.2 (6.1 - 6.3)	6.6 (6.3 - 6.9)
Females, 40–59	1	643	0	6.2 (6.1 - 6.3)	5.2 (5.1 - 5.4)	6.2 (6.1 - 6.3)	6.7 (6.5 - 6.9)	7.5 (7.4 - 7.7)
Females, 40–59	2	605	0	5.8 (5.7 - 6.0)	4.9 (4.8 - 5.1)	5.8 (5.7 - 5.9)	6.3 (6.2 - 6.5)	7.0 (6.6 - 7.5)
Females, 60–79	1	542	0	6.5 (6.3 - 6.6)	5.4 (5.2 - 5.6)	6.4 (6.3 - 6.5)	7.0 (6.8 - 7.2)	7.9 (7.6 - 8.3)
Females, 60–79	2	575	0	5.9 (5.8 - 6.0)	5.0 (4.9 - 5.2)	5.9 (5.8 - 6.0)	6.4 (6.3 - 6.5)	6.9 (6.8 - 7.1)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.19.4

Zinc — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5492	0.78	250 (240 - 270)	67 (58 - 77)	270 (260 - 280)	520 (490 - 540)	1100 (990 - 1100)
Total, 6–79	2	5738	0.45	320 (300 - 340)	86 (77 - 96)	350 (330 - 370)	600 (560 - 640)	1200 (1100 - 1300)
Males, Total 6–79	1	2662	0.34	330 (310 - 340)	100 (90 - 110)	350 (320 - 370)	590 (560 - 620)	1200 (1100 - 1300)
Males, Total 6–79	2	2746	0.18	400 (370 - 440)	130 (110 - 150)	450 (410 - 490)	680 (620 - 740)	1300 (1200 - 1400)
Females, Total 6–79	1	2830	1.20	200 (180 - 220)	51 (44 - 57)	210 (190 - 220)	420 (380 - 460)	930 (830 - 1000)
Females, Total 6–79	2	2992	0.70	250 (230 - 270)	67 (55 - 78)	280 (260 - 310)	480 (450 - 510)	1000 (930 - 1100)

[a] For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.19.5

Zinc — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6311	0.41	320 (300 - 340)	87 (77 - 97)	350 (330 - 370)	600 (560 - 640)	1200 (1100 - 1300)
3–5[b]	1							
3–5	2	573	0	340 (320 - 370)	150 (120 - 170)	360 (330 - 390)	550 (480 - 610)	950 (820 - 1100)
6–11	1	1034	0.19	290 (260 - 330)	98 (78 - 120)	320 (280 - 360)	520 (470 - 560)	860 (790 - 940)
6–11	2	1062	0	360 (330 - 400)	140 (120 - 150)	380 (330 - 420)	610 (540 - 670)	1000 (870 - 1200)
12–19	1	983	0.10	400 (360 - 430)	120 (100 - 150)	450 (410 - 480)	730 (680 - 770)	1300 (1000 - 1600)
12–19	2	1041	0.19	420 (360 - 480)	140 (100 - 180)	450 (380 - 520)	690 (560 - 820)	1300 (1100 - 1500)
20–39	1	1169	1.20	220 (200 - 240)	57 (44 - 70)	220 (190 - 250)	450 (410 - 500)	1000 (900 - 1100)
20–39	2	1321	0.61	300 (270 - 340)	76 (56 - 96)	340 (310 - 380)	550 (500 - 600)	1100 (880 - 1200)
40–59	1	1223	1.39	230 (210 - 260)	59 (48 - 71)	250 (220 - 270)	490 (440 - 550)	1100 (930 - 1200)
40–59	2	1228	0.57	290 (260 - 320)	72 (54 - 91)	330 (300 - 360)	570 (520 - 630)	1200 (1000 - 1300)
60–79	1	1083	0.83	280 (260 - 300)	82 (60 - 100)	290 (260 - 310)	540 (500 - 580)	1100 (930 - 1200)
60–79	2	1086	0.83	330 (300 - 350)	93 (82 - 100)	340 (300 - 380)	630 (570 - 700)	1400 (1100 - 1800)

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[b] Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.19.6

Zinc — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3036	0.16	400 (370 - 440)	130 (110 - 150)	450 (410 - 490)	670 (620 - 730)	1300 (1200 - 1400)
Males, 6–11	1	524	0.38	300 (240 - 360)	100 (70 - 130)	330 (250 - 400)	510 (440 - 590)	830 (770 - 890)
Males, 6–11	2	532	0	380 (340 - 430)	140 (110 - 170)	420 (350 - 490)	600 (510 - 690)	1000 (770 - 1300)
Males, 12–19	1	505	0	450 (410 - 490)	160 (130 - 180)	480 (430 - 530)	740 (700 - 780)	1400 (1100 - 1600)
Males, 12–19	2	542	0.18	520 (440 - 610)	200 (150 - 250)	560 (470 - 650)	830 (640 - 1000)	1400 (1100 - 1600)
Males, 20–39	1	514	0.39	290 (250 - 340)	85 (56 - 110)	310 (240 - 370)	570 (490 - 650)	1100 (1000 - 1300)
Males, 20–39	2	551	0.36	390 (340 - 460)	120[E] (78 - 170)	450 (390 - 510)	680 (580 - 770)	1300 (870 - 1600)
Males, 40–59	1	578	0.52	320 (290 - 340)	95 (78 - 110)	340 (300 - 380)	570 (500 - 630)	1300 (960 - 1600)
Males, 40–59	2	616	0.16	380 (330 - 440)	120[E] (66 - 170)	440 (350 - 520)	670 (570 - 770)	1300 (1200 - 1400)
Males, 60–79	1	541	0.37	350 (310 - 390)	110 (89 - 140)	350 (310 - 400)	590 (490 - 680)	1100 (760 - 1500)
Males, 60–79	2	505	0.20	400 (370 - 430)	130 (100 - 160)	420 (370 - 470)	680 (630 - 730)	1500 (1200 - 1800)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3275	0.64	250 (240 - 270)	69 (58 - 79)	280 (260 - 310)	480 (450 - 510)	1000 (930 - 1100)
Females, 6–11	1	510	0	290 (260 - 320)	92 (76 - 110)	320 (290 - 350)	520 (460 - 570)	920 (780 - 1100)
Females, 6–11	2	530	0	350 (310 - 380)	130 (100 - 160)	340 (300 - 380)	610 (510 - 710)	1000 (860 - 1200)
Females, 12–19	1	478	0.21	340 (300 - 390)	94 (65 - 120)	390 (320 - 450)	710 (600 - 820)	1300 (840 - 1700)
Females, 12–19	2	499	0.20	330 (290 - 390)	93[E] (50 - 140)	350 (300 - 390)	600 (530 - 670)	1100 (970 - 1200)
Females, 20–39	1	655	1.83	160 (140 - 180)	46 (36 - 56)	170 (150 - 190)	340 (290 - 400)	670 (600 - 740)
Females, 20–39	2	770	0.78	230 (200 - 270)	62 (41 - 83)	280 (220 - 330)	450 (390 - 500)	870 (610 - 1100)
Females, 40–59	1	645	2.17	170 (150 - 200)	47 (35 - 58)	180 (140 - 220)	360 (290 - 430)	950 (670 - 1200)
Females, 40–59	2	612	0.98	220 (200 - 240)	54 (40 - 67)	250 (210 - 290)	430 (390 - 460)	860 (680 - 1000)
Females, 60–79	1	542	1.29	220 (190 - 260)	59 (42 - 76)	220 (180 - 260)	500 (420 - 570)	930 (800 - 1100)
Females, 60–79	2	581	1.38	270 (230 - 310)	73 (48 - 98)	280 (250 - 310)	560 (480 - 630)	1400 (880 - 1900)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 8.19.7

Zinc (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5479	0.78	310 (300 - 320)	130 (120 - 140)	320 (310 - 330)	480 (460 - 500)	840 (810 - 880)
Total, 6–79	2	5719	0.45	300 (280 - 310)	130 (120 - 150)	310 (290 - 320)	440 (420 - 460)	770 (730 - 810)
Males, Total 6–79	1	2653	0.34	320 (310 - 340)	140 (130 - 160)	330 (310 - 340)	480 (450 - 510)	810 (770 - 850)
Males, Total 6–79	2	2739	0.18	320 (300 - 340)	150 (130 - 170)	330 (310 - 360)	460 (430 - 490)	770 (720 - 820)
Females, Total 6–79	1	2826	1.20	290 (280 - 310)	110 (100 - 120)	310 (290 - 330)	470 (450 - 500)	890 (810 - 960)
Females, Total 6–79	2	2980	0.70	270 (260 - 280)	120 (110 - 130)	280 (270 - 300)	420 (400 - 440)	760 (690 - 820)

[a] For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 8.19.8

Zinc (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	6291	0.41	300 (290 - 320)	140 (120 - 150)	310 (300 - 330)	460 (430 - 480)	800 (760 - 840)
3–5[b]	1							
3–5	2	572	0	580 (550 - 620)	290 (230 - 350)	630 (600 - 670)	800 (730 - 870)	1300 (1100 - 1500)
6–11	1	1031	0.19	450 (430 - 480)	240 (210 - 260)	460 (440 - 480)	610 (580 - 640)	960 (890 - 1000)
6–11	2	1058	0	410 (390 - 440)	210 (180 - 240)	410 (380 - 450)	580 (500 - 660)	870 (760 - 980)
12–19	1	982	0.10	350 (320 - 370)	160 (140 - 180)	350 (330 - 380)	510 (490 - 530)	830 (740 - 930)
12–19	2	1039	0.19	310 (290 - 340)	150 (130 - 170)	330 (290 - 360)	440 (410 - 480)	670 (580 - 750)
20–39	1	1165	1.20	240 (230 - 260)	110 (93 - 120)	250 (230 - 270)	360 (340 - 380)	600 (560 - 630)
20–39	2	1319	0.61	250 (230 - 270)	120 (110 - 140)	260 (240 - 270)	350 (310 - 390)	580 (510 - 640)
40–59	1	1218	1.40	300 (280 - 320)	120 (110 - 140)	320 (290 - 340)	470 (420 - 510)	820 (760 - 890)
40–59	2	1223	0.57	280 (250 - 300)	110 (93 - 140)	300 (260 - 330)	420 (390 - 450)	730 (660 - 810)
60–79	1	1083	0.83	380 (360 - 410)	160 (130 - 190)	390 (360 - 420)	590 (550 - 630)	1000 (960 - 1100)
60–79	2	1080	0.83	380 (360 - 410)	170 (150 - 190)	390 (370 - 410)	580 (520 - 630)	1200 (970 - 1400)

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[b] Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

Table 8.19.9

Zinc (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	3028	0.17	330 (300 - 350)	150 (130 - 180)	330 (310 - 360)	480 (450 - 500)	790 (740 - 840)
Males, 6–11	1	522	0.38	450 (420 - 480)	240 (220 - 260)	460 (430 - 490)	610 (560 - 670)	910 (830 - 990)
Males, 6–11	2	530	0	420 (380 - 460)	220 (180 - 250)	410 (360 - 460)	580 (430 - 720)	950 (790 - 1100)
Males, 12–19	1	504	0	380 (350 - 410)	200 (170 - 230)	390 (350 - 420)	540 (520 - 560)	850 (730 - 960)
Males, 12–19	2	541	0.18	350 (320 - 380)	190 (160 - 210)	370 (340 - 400)	480 (420 - 530)	690 (550 - 840)
Males, 20–39	1	512	0.39	270 (250 - 290)	120 (100 - 150)	270 (230 - 320)	380 (340 - 420)	610 (570 - 640)
Males, 20–39	2	550	0.36	270 (250 - 300)	150 (120 - 170)	270 (240 - 300)	380 (330 - 440)	590 (520 - 660)
Males, 40–59	1	574	0.52	310 (300 - 330)	140 (130 - 150)	320 (300 - 340)	440 (400 - 490)	740 (640 - 840)
Males, 40–59	2	615	0.16	300 (260 - 350)	130 (90 - 180)	330 (280 - 390)	460 (410 - 510)	720 (630 - 810)
Males, 60–79	1	541	0.37	370 (340 - 400)	170 (140 - 190)	370 (340 - 400)	550 (510 - 600)	990 (890 - 1100)
Males, 60–79	2	503	0.20	390 (360 - 420)	180 (160 - 200)	390 (370 - 410)	590 (520 - 650)	1100 (810 - 1300)
Females, Total 3–79[c]	1							
Females, Total 3–79	2	3263	0.64	280 (270 - 290)	120 (110 - 130)	290 (270 - 300)	430 (410 - 450)	820 (750 - 890)
Females, 6–11	1	509	0	450 (430 - 480)	240 (190 - 280)	460 (430 - 480)	610 (580 - 640)	990 (900 - 1100)
Females, 6–11	2	528	0	410 (380 - 440)	210 (170 - 250)	420 (390 - 450)	580 (520 - 640)	840 (780 - 900)
Females, 12–19	1	478	0.21	310 (290 - 330)	140 (120 - 160)	310 (290 - 320)	470 (420 - 520)	770 (680 - 860)
Females, 12–19	2	498	0.20	280 (250 - 300)	130 (110 - 150)	280 (250 - 310)	410 (350 - 470)	650 (570 - 730)
Females, 20–39	1	653	1.84	220 (200 - 240)	94 (85 - 100)	230 (210 - 250)	340 (300 - 370)	570 (490 - 660)
Females, 20–39	2	769	0.78	230 (210 - 250)	110 (96 - 130)	250 (220 - 270)	330 (290 - 370)	540 (440 - 630)
Females, 40–59	1	644	2.17	290 (260 - 320)	110 (88 - 120)	300 (260 - 340)	490 (440 - 540)	900 (660 - 1100)
Females, 40–59	2	608	0.99	250 (230 - 270)	100 (79 - 130)	260 (240 - 290)	380 (340 - 420)	740 (630 - 850)
Females, 60–79	1	542	1.29	400 (370 - 430)	150[E] (90 - 210)	420 (380 - 460)	620 (590 - 660)	1100 (930 - 1300)
Females, 60–79	2	577	1.39	380 (350 - 410)	160 (130 - 190)	400 (370 - 420)	580 (510 - 650)	1300 (1000 - 1600)

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

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BENZENE METABOLITES SUMMARY AND RESULTS

9

Benzene is a colorless liquid and a highly volatile organic compound that was first isolated and synthesized in the early 1800s (ATSDR, 2007). It is naturally present in ambient air at low concentrations (Health Canada, 2009). Currently, benzene is commercially recovered from both coal and petroleum sources for industrial applications (ATSDR, 2007).

Benzene is released to the environment from natural and anthropogenic sources. It is naturally present at a median concentration of 0.28% by weight in Canadian crude oil, and is formed during the incomplete combustion of organic materials (Drummond, 1991; Environment Canada & Health Canada, 1993). Benzene enters the environment as a result of natural processes including petroleum seepage, weathering of rock and soil, volcanic activity, forest fires, and releases from plant life (Environment Canada & Health Canada, 1993). Anthropogenic sources include the production, storage, use, and transport of isolated benzene, crude oil, and some of its refined products. Examples include evaporative releases from gasoline at service stations and motor vehicle exhaust (Health Canada, 2009). Natural sources are generally considered to be lower contributors than anthropogenic ones to benzene in the environment (Environment Canada & Health Canada, 1993).

Benzene is used widely in industry as a solvent and as an intermediate in the production of a variety of chemicals (Environment Canada & Health Canada, 1993). These chemicals are typically used for the production of end-products including plastics and elastomers, phenol and acetone, and nylon resins (ATSDR, 2007). Benzene is also used at various stages in the manufacturing of synthetic fibres, rubbers, lubricants, dyes, detergents, drugs, and pesticides (ATSDR, 2007).

The general population is exposed to benzene mainly through inhalation of air; higher exposures occur particularly in areas of heavy vehicle traffic and at service stations, and by inhalation of tobacco smoke (ATSDR, 2007). Exposure to benzene in air accounts for an estimated 98% to 99% of total benzene intake for Canadian non-smokers (Health Canada, 2009). In private homes, benzene levels in air have been shown to be higher in homes with attached garages, or where the inhabitants smoke indoors (Héroux et al., 2008; Héroux et al., 2010). Various products containing benzene can also contribute to its presence in indoor air (Environment Canada & Health Canada, 1993). Although low levels of benzene have been detected in tap water and in certain foods and beverages, they do not constitute major sources of exposure for the general population (ATSDR, 2007; Health Canada, 2009).

Following inhalation, benzene is readily absorbed into the blood and is distributed throughout the body concentrating in adipose tissue (EPA, 2002). In the lung and liver, benzene is metabolized into several reactive metabolites including benzene oxide (EPA, 2002; McHale et al., 2012). From benzene oxide, benzene metabolism branches into several alternative metabolic pathways: spontaneous rearrangement produces phenol, a major product; reaction with glutathione ultimately forms *S*-phenylmercapturic acid (*S*-PMA); and an iron-catalyzed reaction leads to the formation of *trans,trans*-muconic acid (*t,t*-MA) (EPA, 2002). Excretion of benzene occurs primarily as conjugated metabolites, and all benzene metabolites may be conjugated with sulphate or glucuronic acid (EPA, 2002). Phenol, *S*-PMA, and *t,t*-MA are considered urinary biomarkers of recent benzene exposure (Boogaard & van Sittert, 1995; Qu et al., 2005; Weisel, 2010). Measurements of *t,t*-MA and *S*-PMA are more sensitive and reliable indicators of benzene exposure because urinary phenol may be a result of dietary or environmental exposure to phenol or other phenolic compounds (ATSDR, 2007).

Exposure to benzene is known to cause a number of health effects in humans. Benzene is hematotoxic in humans and laboratory animals, with bone marrow being the principal target organ (EPA, 2002). Available data indicate that metabolites produced in the liver may be carried to bone marrow where benzene toxicity occurs (EPA, 2002). In rodents, chronic inhalation exposure to benzene has been shown to cause leukemia (EPA, 2002). Epidemiologic studies and case studies provide strong evidence of an association between exposure to high levels of benzene and leukemia risk in occupationally exposed humans (EPA, 2002). The International Agency for Research on Cancer has classified benzene as Group 1, carcinogenic to humans (IARC, 2012). A common mode of action has not been established for hematotoxic and carcinogenic effects; however, it is generally accepted that acute myelogenous leukemia and non-cancer effects are caused by one or more reactive metabolites of benzene (ATSDR, 2007; EPA, 2002; McHale et al., 2012; Smith, 2010).

Benzene has become one of the most intensively regulated substances (Capleton & Levy, 2005). Regulations have been put in place for the permissible concentrations of benzene in gasoline as well as for the emission standards for vehicles in Canada (Canada, 1997; Environment Canada, 2012). Benzene is listed on Schedule 1, List of Toxic Substances, under the *Canadian Environmental Protection Act, 1999* and is a candidate for a full lifecycle management to prevent or minimize its release into the environment (Canada, 1999; Environment Canada & Health Canada, 1993). In 2000–2001, the Canadian Council of Ministers of the Environment endorsed the Canada-wide standard for benzene requiring industry reduction of total benzene emissions and use of best management practices (CCME, 2000; CCME, 2001). With the implementation of the standard, emissions of benzene in ambient air fell by 67% between 1995 and 2003 (CCME, 2000; CCME, 2001). Benzene is also included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011). Health Canada has established a Canadian drinking water quality guideline that sets out the maximum acceptable concentration of benzene based on cancer endpoints and is considered protective of both cancer and non-cancer effects (Health Canada, 2009). Health Canada is also working on a guidance document for benzene in residential indoor air.

Exposure to benzene was assessed in firefighters in Montréal, Quebec by means of urinary measurements of *t,t*-MA. Urine samples were collected from 43 firefighters over a period of 20 hours following the end of a fire (Caux et al., 2002). Among the 43 firefighters in this study, only six had *t,t*-MA concentrations exceeding 1700 µg/g creatinine. This value corresponds to a benzene air concentration almost 1,000 times greater than the average concentration in ambient air (Boogaard & van Sittert, 1995; Environment Canada & Health Canada, 1993).

Benzene metabolites, including phenol, *t,t*-MA and *S*-PMA, were measured in the urine of all Canadian Health Measures Survey participants aged 3 to 79 years in cycle 2 (2009–2011). Data are presented as both mg/L and mg/g creatinine for phenol (Tables 9.1.1 to 9.1.4) and as both µg/L and µg/g creatinine for *t,t*-MA and *S*-PMA (Tables 9.2.1 to 9.3.4). Finding a measurable amount of phenol, *t,t*-MA, or *S*-PMA in urine can be an indicator of exposure to benzene and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary benzene metabolites in the Canadian population.

9.1 PHENOL

Table 9.1.1

Phenol — Geometric means and selected percentiles of urine concentrations (mg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2556	0.16	6.6 (6.2 - 7.0)	1.7 (1.5 - 1.9)	6.6 (6.1 - 7.2)	12 (10 - 13)	34 (26 - 42)
3–5	2	524	0	7.4 (6.5 - 8.6)	2.8 (2.2 - 3.4)	7.7 (6.3 - 9.1)	11 (9.3 - 14)	24[E] (15 - 33)
6–11	2	514	0.58	7.3 (6.7 - 7.9)	3.1 (2.7 - 3.5)	7.5 (6.6 - 8.5)	11 (9.5 - 12)	F
12–19	2	511	0	7.3 (6.5 - 8.2)	2.2 (1.8 - 2.6)	7.7 (6.8 - 8.6)	13 (11 - 14)	30 (25 - 34)
20–39	2	356	0	6.8 (5.4 - 8.5)	1.8 (1.2 - 2.3)	6.6 (5.0 - 8.2)	12[E] (4.3 - 19)	33[E] (19 - 46)
40–59	2	360	0	6.2 (5.5 - 6.9)	1.4[E] (0.85 - 1.9)	6.1 (4.5 - 7.7)	11 (8.3 - 14)	39[E] (23 - 55)
60–79	2	291	0.34	6.2 (5.0 - 7.6)	1.6 (1.2 - 2.0)	6.3 (4.8 - 7.9)	12 (8.4 - 16)	40 (27 - 54)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
E Use data with caution.
F Data is too unreliable to be published.

Table 9.1.2

Phenol — Geometric means and selected percentiles of urine concentrations (mg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1280	0	6.8 (6.2 - 7.6)	1.9 (1.4 - 2.5)	6.8 (6.0 - 7.7)	11 (10 - 13)	39 (28 - 49)
Males, 6–11	2	261	0	7.8 (6.5 - 9.4)	3.4 (2.9 - 3.9)	7.5 (6.3 - 8.8)	9.9 (7.9 - 12)	F
Males, 12–19	2	256	0	7.3 (6.2 - 8.4)	2.3 (1.8 - 2.9)	7.0 (5.5 - 8.6)	13 (11 - 15)	30 (20 - 40)
Males, 20–39	2	167	0	7.3 (5.2 - 10)	2.5[E] (1.5 - 3.4)	7.1 (4.8 - 9.3)	F	x
Males, 40–59	2	194	0	6.2 (4.6 - 8.2)	F	6.2[E] (3.3 - 9.1)	11 (8.3 - 13)	x
Males, 60–79	2	142	0	6.5 (4.8 - 8.7)	1.8[E] (1.0 - 2.5)	6.3 (4.5 - 8.2)	11[E] (6.6 - 16)	x
Females, Total 3–79	2	1276	0.31	6.3 (5.8 - 6.9)	1.6 (1.3 - 1.9)	6.6 (5.9 - 7.2)	12 (10 - 13)	32 (25 - 39)
Females, 6–11	2	253	1.19	6.7 (5.6 - 8.1)	2.3[E] (1.3 - 3.4)	7.8 (6.1 - 9.6)	11 (9.4 - 13)	21 (16 - 27)
Females, 12–19	2	255	0	7.3 (6.1 - 8.9)	2.1[E] (1.3 - 2.9)	8.0 (6.7 - 9.3)	13 (11 - 15)	30 (21 - 38)
Females, 20–39	2	189	0	6.3 (5.0 - 7.9)	1.5 (1.2 - 1.9)	6.3 (4.4 - 8.2)	11[E] (3.9 - 17)	x
Females, 40–59	2	166	0	6.2 (4.9 - 7.9)	1.6[E] (0.83 - 2.3)	6.1[E] (3.8 - 8.3)	12[E] (6.7 - 17)	x
Females, 60–79	2	149	0.67	5.9 (4.4 - 8.0)	1.3[E] (0.68 - 2.0)	6.3[E] (3.7 - 8.9)	14[E] (7.8 - 20)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.
b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
E Use data with caution.
F Data is too unreliable to be published.
x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 9.1.3

Phenol (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (mg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LODa	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2546	0.16	6.5 (6.1 - 6.9)	2.6 (2.4 - 2.9)	5.7 (5.2 - 6.3)	11 (9.8 - 12)	25 (21 - 30)
3–5	2	523	0	13 (12 - 14)	6.9 (6.1 - 7.8)	12 (11 - 14)	17 (16 - 19)	33 (25 - 41)
6–11	2	512	0.59	8.3 (7.3 - 9.5)	4.6 (4.0 - 5.2)	8.0 (6.9 - 9.1)	12 (8.9 - 14)	26^{E} (13 - 39)
12–19	2	509	0	5.6 (5.2 - 6.0)	2.7 (2.4 - 2.9)	5.2 (4.6 - 5.8)	7.7 (6.9 - 8.6)	18 (15 - 20)
20–39	2	354	0	5.8 (4.9 - 7.0)	2.5 (2.0 - 2.9)	5.0 (3.7 - 6.4)	9.0 (6.6 - 12)	21 (14 - 28)
40–59	2	358	0	6.2 (5.5 - 7.1)	2.6 (2.2 - 2.9)	5.4 (4.7 - 6.1)	10 (7.5 - 13)	25^{E} (14 - 37)
60–79	2	290	0.34	7.2 (6.2 - 8.3)	2.5 (2.0 - 3.0)	6.4 (5.4 - 7.5)	11 (7.5 - 15)	31^{E} (15 - 46)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 9.1.4

Phenol (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (mg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1276	0	5.8 (5.3 - 6.3)	2.4 (2.1 - 2.6)	5.2 (4.7 - 5.6)	8.8 (7.9 - 9.7)	25 (19 - 32)
Males, 6–11	2	260	0	8.9 (7.1 - 11)	5.0 (4.6 - 5.4)	7.8 (6.1 - 9.5)	12^{E} (7.3 - 18)	F
Males, 12–19	2	255	0	5.2 (4.7 - 5.7)	2.6 (2.3 - 2.8)	4.7 (4.0 - 5.5)	7.4 (6.2 - 8.6)	17^{E} (10 - 24)
Males, 20–39	2	166	0	5.4 (4.3 - 6.8)	2.2 (1.7 - 2.7)	4.9 (3.4 - 6.5)	8.3 (6.3 - 10)	x
Males, 40–59	2	194	0	5.3 (4.5 - 6.2)	2.3 (1.8 - 2.8)	4.7 (3.8 - 5.6)	7.1 (5.2 - 9.1)	x
Males, 60–79	2	142	0	6.1 (5.0 - 7.4)	2.5 (1.9 - 3.0)	5.1 (4.3 - 6.0)	9.3 (6.3 - 12)	x
Females, Total 3–79	2	1270	0.31	7.2 (6.7 - 7.8)	3.1 (2.6 - 3.6)	6.6 (5.8 - 7.4)	11 (10 - 13)	26 (19 - 33)
Females, 6–11	2	252	1.19	7.8 (6.4 - 9.4)	3.8 (3.2 - 4.4)	8.1 (6.9 - 9.3)	11 (9.5 - 13)	26^{E} (14 - 38)
Females, 12–19	2	254	0	6.0 (5.4 - 6.7)	2.8 (2.2 - 3.4)	5.5 (4.8 - 6.3)	8.6 (7.4 - 9.9)	19 (14 - 24)
Females, 20–39	2	188	0	6.3 (5.1 - 7.8)	3.1 (2.2 - 3.9)	5.3 (3.5 - 7.1)	10 (6.9 - 14)	x
Females, 40–59	2	164	0	7.4 (6.2 - 8.8)	2.9^{E} (1.8 - 4.0)	6.5^{E} (4.0 - 8.9)	12 (8.7 - 15)	x
Females, 60–79	2	148	0.68	8.4 (6.8 - 10)	2.6^{E} (1.2 - 3.9)	7.4^{E} (4.6 - 10)	14 (9.6 - 18)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

9.2 *trans,trans*-MUCONIC ACID (*t,t*-MA)

Table 9.2.1

trans,trans-Muconic acid (*t,t*-MA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LODa	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2523	0.20	64 (57 - 71)	15 (12 - 19)	59 (52 - 66)	130 (110 - 150)	500 (330 - 680)
3–5	2	506	0.40	75 (63 - 91)	20 (15 - 24)	68 (52 - 83)	160 (120 - 200)	670 (510 - 840)
6–11	2	511	0.20	71 (57 - 87)	17 (13 - 21)	63 (41 - 85)	160 (110 - 200)	540 (360 - 720)
12–19	2	506	0	75 (61 - 92)	15[E] (8.4 - 21)	66 (47 - 85)	180[E] (98 - 260)	560 (440 - 680)
20–39	2	355	0.56	62 (48 - 81)	13[E] (6.3 - 19)	70 (54 - 86)	110 (74 - 140)	610[E] (300 - 910)
40–59	2	359	0	65 (53 - 80)	17 (14 - 20)	57 (41 - 73)	140 (97 - 190)	470[E] (200 - 750)
60–79	2	286	0	54 (43 - 67)	14[E] (7.6 - 21)	52 (37 - 67)	100 (75 - 130)	400 (300 - 500)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution..

Table 9.2.2

trans,trans-Muconic acid (*t,t*-MA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1267	0.24	68 (57 - 81)	19 (13 - 25)	66 (54 - 78)	130 (100 - 170)	480 (330 - 630)
Males, 6–11	2	261	0.38	77 (58 - 100)	17[E] (9.8 - 25)	76[E] (30 - 120)	180[E] (110 - 250)	550 (380 - 720)
Males, 12–19	2	255	0	77 (55 - 110)	19[E] (8.6 - 29)	62[E] (33 - 91)	F	530 (360 - 690)
Males, 20–39	2	166	0.60	73[E] (50 - 110)	F	72 (54 - 91)	140[E] (81 - 210)	x
Males, 40–59	2	193	0	65 (51 - 83)	19 (13 - 25)	60[E] (34 - 86)	130 (86 - 170)	x
Males, 60–79	2	142	0	57 (42 - 76)	17[E] (6.2 - 27)	44[E] (26 - 61)	100[E] (49 - 150)	x
Females, Total 3–79	2	1256	0.16	59 (51 - 70)	13 (9.2 - 17)	56 (47 - 64)	120 (86 - 160)	610[E] (330 - 890)
Females, 6–11	2	250	0	64 (48 - 85)	17[E] (11 - 23)	54[E] (33 - 74)	120[E] (64 - 170)	500[E] (180 - 820)
Females, 12–19	2	251	0	73 (57 - 92)	10[E] (4.3 - 16)	67 (48 - 87)	230[E] (110 - 340)	760[E] (370 - 1100)
Females, 20–39	2	189	0.53	53 (38 - 74)	12[E] (5.4 - 18)	57 (38 - 76)	96 (71 - 120)	x
Females, 40–59	2	166	0	65[E] (44 - 96)	16 (11 - 21)	52[E] (18 - 85)	170[E] (96 - 250)	x
Females, 60–79	2	144	0	51 (38 - 68)	10[E] (2.9 - 17)	54 (37 - 72)	110[E] (69 - 150)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 9.2.3

trans,trans-Muconic acid (*t,t*-MA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2513	0.20	64 (58 - 70)	19 (16 - 21)	54 (48 - 61)	120 (93 - 150)	450 (370 - 520)
3–5	2	505	0.40	130 (110 - 160)	37 (33 - 42)	110 (88 - 140)	270 (180 - 360)	1000[E] (560 - 1400)
6–11	2	509	0.20	82 (67 - 100)	25 (21 - 28)	70 (52 - 88)	180[E] (110 - 260)	490 (360 - 630)
12–19	2	504	0	57 (47 - 69)	18 (15 - 20)	43 (29 - 57)	110[E] (66 - 150)	410 (350 - 470)
20–39	2	353	0.57	55 (46 - 66)	17 (14 - 19)	48 (36 - 60)	94 (67 - 120)	430 (300 - 570)
40–59	2	357	0	66 (53 - 82)	19 (14 - 24)	54 (38 - 71)	150[E] (81 - 210)	F
60–79	2	285	0	63 (54 - 73)	21 (18 - 24)	54 (44 - 65)	100 (70 - 130)	400[E] (210 - 590)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 9.2.4

trans,trans-Muconic acid (*t,t*-MA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1263	0.24	59 (50 - 70)	17 (15 - 20)	52 (41 - 64)	110 (77 - 140)	390 (290 - 480)
Males, 6–11	2	260	0.38	88 (71 - 110)	28 (23 - 33)	82 (55 - 110)	200[E] (110 - 280)	540 (350 - 720)
Males, 12–19	2	254	0	55 (39 - 78)	18 (15 - 21)	46[E] (24 - 67)	F	360 (240 - 470)
Males, 20–39	2	165	0.61	56 (40 - 78)	17 (12 - 21)	47[E] (28 - 66)	96[E] (40 - 150)	x
Males, 40–59	2	193	0	56 (45 - 70)	16 (13 - 18)	53[E] (32 - 74)	110 (70 - 150)	x
Males, 60–79	2	142	0	53 (40 - 70)	19 (17 - 22)	48[E] (30 - 67)	88 (57 - 120)	x
Females, Total 3–79	2	1250	0.16	69 (61 - 77)	21 (17 - 24)	55 (48 - 63)	140 (96 - 190)	490 (320 - 650)
Females, 6–11	2	249	0	76 (55 - 110)	23 (18 - 28)	57[E] (35 - 79)	F	490 (340 - 640)
Females, 12–19	2	250	0	60 (50 - 72)	17 (13 - 21)	42 (30 - 54)	140[E] (81 - 200)	470 (320 - 620)
Females, 20–39	2	188	0.53	54 (44 - 67)	16 (14 - 19)	51[E] (31 - 72)	89 (63 - 120)	x
Females, 40–59	2	164	0	77 (55 - 110)	24 (2[illegible] - 28)	56[E] (27 - 86)	200[E] (80 - 320)	x
Females, 60–79	2	143	0	74 (59 - 93)	24 (19 - 28)	66 (46 - 86)	150 (100 - 200)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

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9.3 *S*-PHENYLMERCAPTURIC ACID (*S*-PMA)

Table 9.3.1

S-Phenylmercapturic acid (*S*-PMA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2525	22.10	0.20 (0.18 - 0.23)	<LOD	0.12 (0.095 - 0.15)	0.37 (0.27 - 0.47)	3.5 (2.5 - 4.5)
3–5	2	507	20.32	0.15 (0.13 - 0.17)	<LOD	0.12 (0.094 - 0.14)	0.28^{E} (0.15 - 0.41)	0.64^{E} (0.40 - 0.88)
6–11	2	511	25.24	0.14 (0.11 - 0.17)	<LOD	0.099 (0.083 - 0.12)	0.19^{E} (0.089 - 0.29)	0.58^{E} (0.33 - 0.82)
12–19	2	506	18.97	0.17 (0.15 - 0.20)	<LOD	0.13 (0.094 - 0.16)	0.33 (0.29 - 0.36)	1.1^{E} (0.53 - 1.6)
20–39	2	355	19.44	0.21 (0.17 - 0.27)	<LOD	0.12 (<LOD - 0.16)	0.50^{E} (0.29 - 0.72)	3.0^{E} (1.5 - 4.5)
40–59	2	359	25.91	0.24 (0.18 - 0.31)	<LOD	0.13^{E} (<LOD - 0.20)	F	5.2^{E} (3.2 - 7.3)
60–79	2	287	23.69	0.19 (0.15 - 0.23)	<LOD	0.12 (0.094 - 0.15)	0.32^{E} (0.18 - 0.46)	3.4^{E} (1.3 - 5.4)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 9.3.2

S-Phenylmercapturic acid (*S*-PMA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1267	20.21	0.23 (0.20 - 0.26)	<LOD	0.13 (0.10 - 0.16)	0.47^{E} (0.27 - 0.68)	3.9^{E} (2.5 - 5.4)
Males, 6–11	2	261	26.44	0.13 (0.11 - 0.17)	<LOD	0.099 (0.080 - 0.12)	0.18 (0.12 - 0.24)	0.46^{E} (0.26 - 0.65)
Males, 12–19	2	255	17.65	0.17 (0.14 - 0.21)	<LOD	0.12 (<LOD - 0.16)	0.30 (0.25 - 0.35)	F
Males, 20–39	2	166	16.27	0.23 (0.18 - 0.31)	<LOD	0.13^{E} (<LOD - 0.19)	0.56^{E} (0.25 - 0.88)	x
Males, 40–59	2	193	19.69	0.30^{E} (0.20 - 0.45)	<LOD	F	F	x
Males, 60–79	2	142	16.90	0.20 (0.15 - 0.27)	<LOD	0.12 (0.086 - 0.16)	F	x
Females, Total 3–79	2	1258	24.01	0.18 (0.15 - 0.23)	<LOD	0.11 (<LOD - 0.14)	0.34 (0.23 - 0.44)	2.5^{E} (0.89 - 4.1)
Females, 6–11	2	250	24.00	0.14 (0.12 - 0.18)	<LOD	0.10 (<LOD - 0.12)	0.29^{E} (0.17 - 0.41)	0.64^{E} (0.35 - 0.93)
Females, 12–19	2	251	20.32	0.18 (0.14 - 0.23)	<LOD	0.14^{E} (<LOD - 0.20)	0.36 (0.28 - 0.44)	0.97^{E} (0.40 - 1.5)
Females, 20–39	2	189	22.22	0.20 (0.15 - 0.26)	<LOD	0.10^{E} (<LOD - 0.14)	0.48^{E} (0.19 - 0.77)	x
Females, 40–59	2	166	33.13	0.19^{E} (0.12 - 0.29)	<LOD	F	F	x
Females, 60–79	2	145	30.34	0.17 (0.12 - 0.24)	<LOD	0.12 (0.089 - 0.15)	0.32^{E} (0.12 - 0.52)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 9.3.3

S-Phenylmercapturic acid (*S*-PMA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2515	22.19	0.20 (0.17 - 0.24)	<LOD	0.18 (0.14 - 0.21)	0.38 (0.30 - 0.46)	3.1 (2.1 - 4.2)
3–5	2	506	20.36	0.27 (0.24 - 0.30)	<LOD	0.26 (0.21 - 0.31)	0.43 (0.36 - 0.50)	0.91 (0.69 - 1.1)
6–11	2	509	25.34	0.16 (0.13 - 0.19)	<LOD	0.15 (0.12 - 0.19)	0.25 (0.19 - 0.31)	0.60 (0.40 - 0.80)
12–19	2	504	19.05	0.13 (0.12 - 0.15)	<LOD	0.13 (0.11 - 0.14)	0.22 (0.19 - 0.26)	0.78 (0.50 - 1.1)
20–39	2	353	19.55	0.19 (0.14 - 0.26)	<LOD	0.14 (<LOD - 0.19)	0.44^{E} (0.22 - 0.65)	2.9^{E} (1.8 - 4.1)
40–59	2	357	26.05	0.24 (0.18 - 0.32)	<LOD	0.20 (<LOD - 0.25)	0.44^{E} (<LOD - 0.67)	4.3^{E} (1.5 - 7.0)
60–79	2	286	23.78	0.22 (0.18 - 0.27)	<LOD	0.19 (0.15 - 0.22)	0.36 (0.27 - 0.44)	3.1^{E} (1.4 - 4.8)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 9.3.4

S-Phenylmercapturic acid (*S*-PMA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1263	20.27	0.20 (0.16 - 0.24)	<LOD	0.15 (0.12 - 0.18)	0.38^{E} (0.24 - 0.53)	3.1^{E} (1.1 - 5.1)
Males, 6–11	2	260	26.54	0.15 (0.12 - 0.19)	<LOD	0.14 (0.094 - 0.19)	0.25 (0.18 - 0.32)	0.55 (0.43 - 0.68)
Males, 12–19	2	254	17.72	0.12 (0.10 - 0.14)	<LOD	0.12 (<LOD - 0.14)	0.21 (0.17 - 0.24)	F
Males, 20–39	2	165	16.36	0.19 (0.13 - 0.26)	<LOD	0.13^{E} (<LOD - 0.18)	F	x
Males, 40–59	2	193	19.69	0.25^{E} (0.16 - 0.38)	<LOD	0.17^{E} (<LOD - 0.26)	F	x
Males, 60–79	2	142	16.90	0.19 (0.14 - 0.26)	<LOD	0.15^{E} (0.090 - 0.20)	0.29^{E} (<LOD - 0.39)	x
Females, Total 3–79	2	1252	24.12	0.21 (0.16 - 0.27)	<LOD	0.18 (<LOD - 0.23)	0.37 (0.28 - 0.47)	3.2^{E} (1.1 - 5.3)
Females, 6–11	2	249	24.10	0.17 (0.14 - 0.21)	<LOD	0.16 (<LOD - 0.19)	0.25^{E} (0.15 - 0.35)	0.71^{E} (0.39 - 1.0)
Females, 12–19	2	250	20.40	0.15 (0.11 - 0.19)	<LOD	0.14 (<LOD - 0.16)	0.23^{E} (0.14 - 0.32)	0.68^{E} (0.32 - 1.1)
Females, 20–39	2	188	22.34	0.20^{E} (0.14 - 0.29)	<LOD	0.17^{E} (<LOD - 0.24)	0.43^{E} (0.23 - 0.62)	x
Females, 40–59	2	164	33.54	0.22^{E} (0.14 - 0.34)	<LOD	0.22^{E} (<LOD - 0.31)	0.42^{E} (<LOD - 0.60)	x
Females, 60–79	2	144	30.56	0.25 (0.19 - 0.34)	<LOD	0.21 (0.14 - 0.27)	0.36^{E} (0.16 - 0.56)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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CHLOROPHENOLS SUMMARY AND RESULTS

10

Chlorophenols are the building blocks of many chlorinated aromatic chemicals. There are 19 different chlorophenols that are grouped into five basic types according to the number of chlorine groups (from one to five). In cycle 2 of the Canadian Health Measures Survey (CHMS), five chlorophenols were measured including two dichlorophenols, two trichlorophenols, and pentachlorophenol (Table 10.1).

Table 10.1

Chlorophenols measured in the Canadian Health Measures Survey cycle 2 (2009–2011).

Chlorophenol	CASRN
2,4-Dichlorophenol (2,4-DCP)	120-83-2
2,5-Dichlorophenol (2,5-DCP)	583-78-8
2,4,5-Trichlorophenol (2,4,5-TCP)	95-95-4
2,4,6-Trichlorophenol (2,4,6-TCP)	88-06-2
Pentachlorophenol (PCP)	87-86-5

In general, chlorophenols have been used directly as pesticides or as intermediates in the production of pesticides of various types, including bactericides, algicides, molluscides, acaricides (targeting ticks and mites), fungicides, and mould inhibitors (IPCS, 1989). 2,4-DCP and 2,4,5-TCP have been primarily used as intermediates in the production of phenoxy herbicides, specifically 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) (ATSDR, 1999). 2,4-D is found in over 150 agricultural and residential products in Canada, whereas 2,4,5-T was removed from the list of herbicides registered for use under the *Pest Control Products Act* in 1985 (Canada, 2006; Health Canada, 2008; Health Canada, 2012a). PCP is primarily used as a wood preservative in Canada to treat electrical utility poles and cross-arms (Health Canada, 2011). Some chlorophenols have also been used as intermediates in the production of certain dyes and pharmaceuticals and for less specific uses, such as general antiseptics and disinfectants (IPCS, 1989). Chlorophenols are no longer manufactured in Canada but continue to be imported (Health Canada, 1987; Health Canada, 2012b). Currently, 13 pesticide products containing PCP plus related active chlorophenols are registered for use in Canada under the *Pest Control Products Act* (Canada, 2006; Health Canada, 2012b).

Although some chlorophenols occur naturally, these sources are not significant contributors to overall environmental levels (IPCS, 1989). Significant amounts of chlorophenols can be formed and released into the environment from the chlorination of waste water and drinking water and the incineration of municipal waste (ATSDR, 1999; IPCS, 1989). Chlorophenols may also enter the environment as a result of the degradation of applied pesticides made from chlorophenols (ATSDR, 1999).

People can be exposed to chlorophenols following ingestion of food, inhalation of air, and ingestion of drinking water that has been disinfected with chlorine (ATSDR, 2001; IPCS, 1989). In Canada, food contributes to approximately 40% of the overall exposure to chlorophenols, whereas air (indoor and ambient) and drinking water contribute to approximately 30% and 20%, respectively (Health Canada, 1987). For PCP, food sources are estimated to account for 74% to 89% of total daily intake with air accounting for 10% to 25%; water, soil, and household dust were found to be negligible sources (Coad, 1992). In Canada, concentrations of chlorophenols in drinking water are generally quite low and vary considerably from one location to another (Health Canada, 1987; Sithole & Williams, 1986). Other sources of human exposure to chlorophenols include dermal contact with chlorophenol-containing products such as treated wood (ATSDR, 2001; Health Canada, 1987).

Chlorophenols, including PCP, can be rapidly absorbed following inhalation, ingestion, and dermal contact (ATSDR, 2001; CDC, 2009; Health Canada, 1987; IPCS, 1989). The major metabolic transformation for chlorophenols is through conjugation with sulphate or glucuronate in the liver, prior to excretion in the urine (ATSDR, 2001; IPCS, 1989). Chlorophenol metabolites accumulate most often in the kidney and liver; however, they may also be deposited in the brain and adipose tissue (ATSDR, 2001; IPCS, 1989). Approximately 80% to 90% of chlorophenols are eliminated through the urine in both free and conjugated forms, with smaller amounts eliminated in the feces (IPCS, 1989). A single dose of chlorophenols is virtually eliminated within 1 to several days, although elimination rates appear to be even more rapid for some tissues (IPCS, 1989). Urinary levels of chlorophenols are useful biomarkers of exposure; however, they are not unique to chlorophenol exposure because they are also detectable in urine after exposure to certain pesticides (ATSDR, 1999; ATSDR, 2001).

Chronic health effects that have been reported in those involved in the manufacture of chlorophenols include eye, nose, and airway irritation, dermatitis, chloracne, and porphyria (IPCS, 1989). A few epidemiological studies have shown associations between occupational exposure to chlorophenols and soft tissue sarcoma, malignant lymphoma, and nasal and nasopharyngeal cancer (IPCS, 1989). However, other epidemiology studies have shown no associations, and data from animal studies are equally conflicting (IPCS, 1989). The International Agency for Research on Cancer has classified combined exposure to polychlorophenols (2,4-DCP, 2,4,5-TCP, 2,4,6-TCP, and PCP) as well as PCP alone as Group 2B, possibly carcinogenic to humans (IARC, 1991; IARC, 1999). Health Canada has not classified chlorophenols as to their carcinogenic potential because of the inadequacy of available data; however, 2,4,6-TCP has been classified as Group II, probably carcinogenic (Health Canada, 1987).

As part of the Chemicals Management Plan under the *Canadian Environmental Protection Act, 1999* (CEPA 1999), PCP was identified as a high-priority substance; the final screening assessment was published in August 2009 (Canada, 1999; Canada, 2011; Environment Canada & Health Canada, 2009). Although PCP is considered to be inherently toxic to humans, the assessment found no information on non-pesticidal uses or releases of PCP in Canada and concluded that the likelihood of exposure to PCP in Canada resulting from non-pesticidal uses is low (Environment Canada & Health Canada, 2009). To control possible future releases, the Government of Canada published Significant New Activity provisions under CEPA 1999 for this substance. These provisions require that any proposed new manufacture, import, or use, other than those covered under the *Pest Control Products Act*, be subject to assessment prior to initiation of this activity in Canada (Canada, 2006; Canada, 2009). The Pest Management Regulatory Agency recently completed a re-evaluation of PCP and granted continued registration of PCP for sale and use as a heavy-duty wood preservative in Canada (Health Canada, 2012b). As part of the Chemicals Management Plan under CEPA 1999, 2,4-DCP remains a priority for assessment (Environment Canada, 2011).

Health Canada has established Canadian drinking water quality guidelines that set out the maximum acceptable concentrations of 2,4-DCP, 2,4,6-TCP, and PCP (Health Canada, 1987; Health Canada, 2012c).

In a study carried out in rural and urban areas throughout Saskatchewan, PCP levels were measured in 24-hour urine samples from non-occupationally exposed individuals (Treble & Thompson, 1996). Out of a total of 69 male and female participants 6 to 87 years of age, the average urinary PCP level was 0.75 µg/L and ranged from 0.05 to 3.6 µg/L (Treble & Thompson, 1996).

2,4-DCP, 2,5-DCP, 2,4,5-TCP, 2,4,6-TCP, and PCP were measured in the urine of all CHMS cycle 2 (2009–2011) participants aged 3 to 79 years. Data are presented as both µg/L and µg/g creatinine (Tables 10.1.1 to 10.5.4). Finding a measurable amount of chlorophenols in urine can be an indicator of exposure to chlorophenols and does not necessarily mean that an adverse health effect will occur. These data provide baseline urinary levels for five chlorophenols in the Canadian population.

10.1 2,4-DICHLOROPHENOL (2,4-DCP)

Table 10.1.1

2,4-Dichlorophenol (2,4-DCP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5479	21.81	0.94 (0.83 - 1.1)	<LOD	0.83 (0.68 - 0.97)	2.2 (1.8 - 2.6)	8.9 (7.7 - 10)
Total, 6–79	2	2022	11.92	1.2 (0.97 - 1.4)	<LOD	1.0 (0.86 - 1.1)	2.3 (1.7 - 2.9)	12^{E} (6.8 - 18)
Males, Total 6–79	1	2661	18.90	1.0 (0.91 - 1.2)	<LOD	0.97 (0.81 - 1.1)	2.4 (2.0 - 2.8)	9.1 (7.8 - 10)
Males, Total 6–79	2	1016	10.04	1.3 (1.1 - 1.6)	<LOD	1.1 (0.95 - 1.2)	2.9^{E} (1.8 - 3.9)	F
Females, Total 6–79	1	2818	24.56	0.85 (0.75 - 0.97)	<LOD	0.71 (0.60 - 0.82)	1.9 (1.5 - 2.3)	8.5 (6.9 - 10)
Females, Total 6–79	2	1006	13.82	1.0 (0.79 - 1.3)	<LOD	0.92 (0.69 - 1.2)	1.9 (1.3 - 2.4)	13^{E} (5.5 - 21)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 10.1.2

2,4-Dichlorophenol (2,4-DCP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2545	12.14	1.2 (0.98 - 1.4)	<LOD	1.0 (0.86 - 1.1)	2.3 (1.7 - 2.9)	12^{E} (7.1 - 18)
3–5[b]	1							
3–5	2	523	13.00	1.2 (0.99 - 1.5)	<LOD	1.0 (0.84 - 1.2)	2.1 (1.6 - 2.6)	F
6–11	1	1029	22.35	0.89 (0.73 - 1.1)	<LOD	0.73 (0.62 - 0.84)	1.7 (1.2 - 2.2)	9.4^{E} (3.2 - 16)
6–11	2	513	12.09	1.1 (0.94 - 1.4)	<LOD	0.99 (0.85 - 1.1)	2.0 (1.4 - 2.6)	9.5^{E} (4.7 - 14)
12–19	1	981	17.02	1.1 (0.90 - 1.3)	<LOD	0.97 (0.78 - 1.2)	2.4 (2.0 - 2.8)	13 (9.3 - 16)
12–19	2	508	6.30	1.5 (1.3 - 1.8)	0.41^{E} (<LOD - 0.57)	1.2 (0.93 - 1.5)	3.0 (2.1 - 3.8)	12^{E} (7.4 - 17)
20–39	1	1166	22.04	0.95 (0.83 - 1.1)	<LOD	0.90 (0.72 - 1.1)	2.2 (1.8 - 2.7)	7.3 (5.8 - 8.8)
20–39	2	351	13.68	1.1 (0.87 - 1.5)	<LOD	1.1 (0.83 - 1.3)	2.4^{E} (1.2 - 3.6)	F
40–59	1	1222	24.06	0.90 (0.80 - 1.0)	<LOD	0.76 (0.60 - 0.92)	2.2 (1.8 - 2.6)	8.9 (7.5 - 10)
40–59	2	359	14.76	1.2 (0.89 - 1.6)	<LOD	1.1 (0.82 - 1.3)	2.2^{E} (0.94 - 3.4)	F
60–79	1	1081	22.85	0.95 (0.77 - 1.2)	<LOD	0.78 (0.56 - 0.99)	2.3 (1.5 - 3.0)	10 (6.5 - 14)
60–79	2	291	15.81	0.96 (0.81 - 1.1)	<LOD	0.73 (0.61 - 0.85)	2.0^{E} (1.2 - 2.8)	9.4^{E} (4.2 - 15)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 10.1.3

2,4-Dichlorophenol (2,4-DCP) — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1276	10.03	1.3 (1.1 - 1.6)	F	1.1 (0.95 - 1.2)	2.9[E] (1.8 - 3.9)	F
Males, 6–11	1	525	23.05	0.85 (0.68 - 1.1)	<LOD	0.72 (0.55 - 0.89)	1.9 (1.3 - 2.4)	7.7[E] (4.7 - 11)
Males, 6–11	2	261	11.11	1.2 (0.91 - 1.6)	<LOD	0.99[E] (0.60 - 1.4)	F	12[E] (5.9 - 19)
Males, 12–19	1	504	15.28	1.1 (0.92 - 1.3)	<LOD	0.99 (0.77 - 1.2)	2.6 (2.0 - 3.2)	13 (8.5 - 17)
Males, 12–19	2	253	7.11	1.7 (1.3 - 2.3)	0.47 (0.31 - 0.63)	1.3 (0.90 - 1.7)	3.4 (2.2 - 4.5)	F
Males, 20–39	1	513	19.10	1.0 (0.85 - 1.3)	<LOD	1.0 (0.74 - 1.3)	2.4 (1.7 - 3.1)	8.0 (5.6 - 10)
Males, 20–39	2	167	12.57	1.3[E] (0.89 - 1.9)	<LOD	1.2[E] (0.67 - 1.7)	3.0[E] (1.2 - 4.8)	x
Males, 40–59	1	578	18.17	1.0 (0.90 - 1.2)	<LOD	0.88 (0.67 - 1.1)	2.4 (2.0 - 2.9)	9.5 (7.8 - 11)
Males, 40–59	2	193	9.33	1.3 (0.96 - 1.8)	0.34[E] (<LOD - 0.51)	1.1 (0.91 - 1.3)	2.9[E] (1.1 - 4.6)	x
Males, 60–79	1	541	18.85	1.1 (0.88 - 1.4)	<LOD	0.95 (0.65 - 1.3)	2.6 (1.8 - 3.4)	11[E] (6.0 - 17)
Males, 60–79	2	142	11.27	1.2 (0.87 - 1.7)	<LOD[E] (<LOD - 0.36)	0.81 (0.60 - 1.0)	2.5[E] (0.78 - 4.3)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1269	14.26	1.0 (0.80 - 1.3)	<LOD	0.92 (0.69 - 1.1)	1.8 (1.3 - 2.4)	13[E] (5.4 - 20)
Females, 6–11	1	504	21.63	0.93 (0.76 - 1.1)	<LOD	0.74 (0.63 - 0.84)	1.6 (1.1 - 2.2)	F
Females, 6–11	2	252	13.10	1.0 (0.77 - 1.4)	<LOD	0.97 (0.66 - 1.3)	1.8 (1.2 - 2.5)	8.6[E] (3.0 - 14)
Females, 12–19	1	477	18.87	1.1 (0.82 - 1.4)	<LOD	0.93 (0.70 - 1.2)	2.2 (1.5 - 3.0)	12[E] (5.1 - 20)
Females, 12–19	2	255	5.49	1.3 (1.0 - 1.8)	0.38[E] (<LOD - 0.57)	1.1 (0.70 - 1.5)	2.2[E] (1.0 - 3.3)	11[E] (6.4 - 15)
Females, 20–39	1	653	24.35	0.87 (0.75 - 1.0)	<LOD	0.78 (0.62 - 0.93)	2.0 (1.4 - 2.5)	6.9 (5.0 - 8.9)
Females, 20–39	2	184	14.67	0.99 (0.72 - 1.3)	<LOD	0.99[E] (0.60 - 1.4)	2.0[E] (1.1 - 2.9)	x
Females, 40–59	1	644	29.35	0.78 (0.68 - 0.90)	<LOD	0.63 (0.50 - 0.76)	1.9 (1.4 - 2.5)	8.6 (6.5 - 11)
Females, 40–59	2	166	21.08	1.1[E] (0.64 - 1.8)	<LOD	0.96[E] (0.46 - 1.5)	F	x
Females, 60–79	1	540	26.85	0.80 (0.64 - 1.0)	<LOD	0.62 (0.46 - 0.78)	1.7[E] (0.89 - 2.5)	9.2 (6.2 - 12)
Females, 60–79	2	149	20.13	0.78 (0.61 - 0.99)	<LOD	0.63[E] (0.37 - 0.89)	1.4[E] (0.40 - 2.4)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 10.1.4

2,4-Dichlorophenol (2,4-DCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5465	21.87	1.1 (0.94 - 1.2)	<LOD	0.91 (0.76 - 1.1)	2.3 (1.9 - 2.8)	9.6 (8.2 - 11)
Total, 6–79	2	2013	11.97	1.1 (0.91 - 1.2)	<LOD	0.89 (0.70 - 1.1)	2.0 (1.5 - 2.5)	9.8 (6.3 - 13)
Males, Total 6–79	1	2652	18.97	0.98 (0.86 - 1.1)	<LOD	0.84 (0.69 - 0.98)	2.1 (1.6 - 2.6)	8.3 (6.9 - 9.6)
Males, Total 6–79	2	1013	10.07	1.1 (0.90 - 1.3)	<LOD	0.88 (0.75 - 1.0)	2.0[E] (1.3 - 2.7)	12[E] (4.6 - 20)
Females, Total 6–79	1	2813	24.60	1.2 (1.0 - 1.3)	<LOD	0.97 (0.80 - 1.1)	2.6 (2.1 - 3.0)	11 (7.7 - 14)
Females, Total 6–79	2	1000	13.90	1.1 (0.86 - 1.3)	<LOD	0.95 (0.66 - 1.2)	2.0 (1.3 - 2.6)	9.8 (6.9 - 13)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 10.1.5

2,4-Dichlorophenol (2,4-DCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2535	12.19	1.1 (0.94 - 1.3)	<LOD	0.94 (0.75 - 1.1)	2.1 (1.6 - 2.6)	10 (6.4 - 14)
3–5[b]	1							
3–5	2	522	13.03	2.0 (1.7 - 2.4)	<LOD	1.8 (1.5 - 2.1)	3.3 (2.8 - 3.9)	F
6–11	1	1026	22.42	1.3 (1.1 - 1.6)	<LOD	1.1 (0.86 - 1.3)	2.5 (1.9 - 3.1)	13[E] (6.3 - 20)
6–11	2	511	12.13	1.3 (1.0 - 1.6)	<LOD	1.1 (0.82 - 1.4)	2.4[E] (1.5 - 3.4)	10[E] (4.6 - 15)
12–19	1	979	17.06	0.89 (0.79 - 1.0)	<LOD	0.78 (0.65 - 0.91)	1.7 (1.4 - 2.1)	9.4 (7.5 - 11)
12–19	2	506	6.32	1.1 (0.96 - 1.4)	0.31 (<LOD - 0.40)	0.96 (0.80 - 1.1)	2.1 (1.5 - 2.6)	9.7[E] (5.9 - 13)
20–39	1	1162	22.12	0.99 (0.88 - 1.1)	<LOD	0.88 (0.67 - 1.1)	2.1 (1.7 - 2.5)	8.0 (6.2 - 9.9)
20–39	2	349	13.75	0.93 (0.75 - 1.2)	<LOD	0.82 (0.59 - 1.0)	1.9[E] (1.1 - 2.6)	6.7[E] (2.3 - 11)
40–59	1	1217	24.16	1.1 (0.94 - 1.2)	<LOD	0.85 (0.73 - 0.96)	2.5 (1.8 - 3.2)	9.8 (6.9 - 13)
40–59	2	357	14.85	1.1 (0.85 - 1.5)	<LOD	0.95[E] (0.57 - 1.3)	2.3[E] (1.1 - 3.5)	12[E] (6.5 - 18)
60–79	1	1081	22.85	1.2 (0.99 - 1.6)	<LOD	1.0 (0.77 - 1.3)	2.8 (2.1 - 3.6)	12[E] (6.7 - 17)
60–79	2	290	15.86	1.1 (0.87 - 1.3)	<LOD	0.79 (0.53 - 1.0)	1.9 (1.4 - 2.4)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 10.1.6

2,4-Dichlorophenol (2,4-DCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1272	10.06	1.1 (0.92 - 1.3)	<LOD (<LOD - 0.36)	0.88 (0.75 - 1.0)	2.2 (1.5 - 2.9)	12^{E} (5.4 - 19)
Males, 6–11	1	523	23.14	1.2 (0.99 - 1.4)	<LOD	1.1 (0.88 - 1.3)	2.3 (1.7 - 2.8)	10 (6.7 - 14)
Males, 6–11	2	260	11.15	1.4 (1.0 - 1.8)	<LOD	1.2^{E} (0.67 - 1.7)	F	12^{E} (4.9 - 20)
Males, 12–19	1	503	15.31	0.89 (0.75 - 1.1)	<LOD	0.80 (0.63 - 0.97)	1.9 (1.4 - 2.4)	8.4^{E} (4.7 - 12)
Males, 12–19	2	252	7.14	1.2 (0.91 - 1.6)	0.27^{E} (0.10 - 0.43)	0.98 (0.70 - 1.3)	2.1 (1.4 - 2.9)	14^{E} (<LOD - 24)
Males, 20–39	1	511	19.18	0.90 (0.75 - 1.1)	<LOD	0.78 (0.57 - 0.99)	1.9 (1.3 - 2.6)	8.0 (6.2 - 9.9)
Males, 20–39	2	166	12.65	0.93 (0.67 - 1.3)	<LOD	0.82 (0.59 - 1.0)	1.9^{E} (0.76 - 3.0)	x
Males, 40–59	1	574	18.29	0.97 (0.83 - 1.1)	<LOD	0.82 (0.70 - 0.93)	2.0^{E} (1.1 - 2.8)	7.5^{E} (4.0 - 11)
Males, 40–59	2	193	9.33	1.1 (0.82 - 1.4)	0.32 (<LOD - 0.39)	0.88 (0.64 - 1.1)	2.4^{E} (0.91 - 3.9)	x
Males, 60–79	1	541	18.85	1.1 (0.91 - 1.4)	<LOD	0.98 (0.64 - 1.3)	2.8 (2.0 - 3.5)	11 (7.1 - 14)
Males, 60–79	2	142	11.27	1.1 (0.83 - 1.5)	<LOD (<LOD - 0.39)	0.88^{E} (0.54 - 1.2)	1.9^{E} (0.84 - 3.0)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1263	14.33	1.1 (0.88 - 1.3)	<LOD	0.96 (0.69 - 1.2)	2.0 (1.4 - 2.7)	9.8 (7.0 - 13)
Females, 6–11	1	503	21.67	1.4 (1.1 - 1.8)	<LOD	1.0 (0.74 - 1.3)	2.9^{E} (1.7 - 4.1)	F
Females, 6–11	2	251	13.15	1.2 (0.83 - 1.6)	<LOD	1.1 (0.77 - 1.4)	2.3^{E} (1.5 - 3.2)	F
Females, 12–19	1	476	18.91	0.90 (0.76 - 1.1)	<LOD	0.77 (0.60 - 0.94)	1.5^{E} (0.93 - 2.1)	9.5 (7.0 - 12)
Females, 12–19	2	254	5.51	1.1 (0.89 - 1.3)	0.33 (<LOD - 0.40)	0.95 (0.79 - 1.1)	2.0^{E} (0.91 - 3.1)	7.9^{E} (5.0 - 11)
Females, 20–39	1	651	24.42	1.1 (0.94 - 1.3)	<LOD	0.99 (0.74 - 1.2)	2.4 (1.7 - 3.0)	8.2 (5.3 - 11)
Females, 20–39	2	183	14.75	0.93 (0.72 - 1.2)	<LOD	0.87^{E} (0.48 - 1.3)	1.6^{E} (0.75 - 2.4)	x
Females, 40–59	1	643	29.39	1.2 (1.0 - 1.4)	<LOD	0.90 (0.72 - 1.1)	2.7 (2.2 - 3.1)	13^{E} (7.2 - 19)
Females, 40–59	2	164	21.34	1.2^{E} (0.78 - 1.9)	<LOD	1.2^{E} (0.50 - 1.8)	F	x
Females, 60–79	1	540	26.85	1.3 (1.0 - 1.7)	<LOD	1.1 (0.83 - 1.3)	2.8^{E} (1.8 - 3.9)	14^{E} (6.7 - 22)
Females, 60–79	2	148	20.27	1.0 (0.73 - 1.5)	<LOD	0.76^{E} (0.44 - 1.1)	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

10.2 2,5-DICHLOROPHENOL (2,5-DCP)

Table 10.2.1

2,5-Dichlorophenol (2,5-DCP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LODa	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2544	4.05	5.5 (4.4 - 6.9)	0.84 (0.62 - 1.0)	5.0 (3.7 - 6.2)	15 (12 - 19)	77^E (35 - 120)
3–5	2	521	7.87	4.1^E (2.7 - 6.0)	F	2.7^E (1.5 - 3.8)	9.8^E (4.3 - 15)	F
6–11	2	514	2.14	4.7^E (3.1 - 7.0)	0.69^E (0.41 - 0.96)	3.5^E (2.0 - 5.1)	F	98^E (45 - 150)
12–19	2	509	1.96	5.8^E (3.8 - 8.8)	0.90^E (0.45 - 1.4)	4.8^E (2.5 - 7.2)	14^E (5.6 - 22)	F
20–39	2	354	2.82	6.0 (4.6 - 8.0)	0.95^E (0.59 - 1.3)	4.8^E (3.0 - 6.6)	21^E (12 - 30)	F
40–59	2	358	5.03	5.3 (4.2 - 6.8)	0.85^E (0.47 - 1.2)	5.5 (3.7 - 7.4)	15 (11 - 19)	F
60–79	2	288	4.51	5.7^E (3.8 - 8.5)	0.73^E (<LOD - 1.2)	5.6^E (3.3 - 7.9)	13^E (7.2 - 20)	98 (65 - 130)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 10.2.2

2,5-Dichlorophenol (2,5-DCP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1272	3.77	6.2 (4.8 - 8.0)	0.83^E (0.53 - 1.1)	5.8 (4.1 - 7.5)	18 (12 - 23)	95^E (33 - 160)
Males, 6–11	2	261	2.68	5.4^E (2.9 - 9.8)	0.66^E (0.39 - 0.92)	F	F	99^E (29 - 170)
Males, 12–19	2	254	1.18	5.9^E (3.4 - 10)	F	4.6^E (1.4 - 7.7)	F	130^E (62 - 200)
Males, 20–39	2	167	1.20	7.4 (5.3 - 10)	1.2^E (0.52 - 2.0)	7.5^E (3.9 - 11)	24^E (14 - 33)	x
Males, 40–59	2	192	4.17	5.9^E (3.8 - 9.2)	F	6.2^E (3.9 - 8.5)	15^E (8.3 - 23)	x
Males, 60–79	2	139	2.88	5.9^E (3.9 - 8.8)	F	5.4^E (3.4 - 7.3)	14^E (7.3 - 22)	x
Females, Total 3–79	2	1272	4.32	5.0 (3.8 - 6.5)	0.84 (0.60 - 1.1)	4.3 (3.0 - 5.7)	13 (8.8 - 18)	65^E (39 - 92)
Females, 6–11	2	253	1.58	4.1^E (2.8 - 6.0)	0.75^E (0.33 - 1.2)	3.2^E (1.6 - 4.8)	8.6^E (3.5 - 14)	84^E (38 - 130)
Females, 12–19	2	255	2.75	5.7 (4.0 - 8.3)	1.1^E (0.62 - 1.5)	4.8^E (2.7 - 7.0)	13^E (5.9 - 20)	65^E (33 - 96)
Females, 20–39	2	187	4.28	4.9 (3.4 - 7.1)	0.87^E (0.55 - 1.2)	3.7^E (1.9 - 5.5)	18^E (5.1 - 31)	x
Females, 40–59	2	166	6.02	4.9^E (3.1 - 7.5)	0.85^E (0.38 - 1.3)	F	14^E (7.2 - 20)	x
Females, 60–79	2	149	6.04	5.6^E (3.2 - 9.6)	F	6.1^E (2.6 - 9.6)	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 10.2.3

2,5-Dichlorophenol (2,5-DCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2534	4.06	5.3 (4.3 - 6.6)	0.94 (0.75 - 1.1)	4.3 (3.1 - 5.4)	15 (10 - 19)	69^{E} (32 - 110)
3–5	2	520	7.88	6.9^{E} (4.6 - 10)	1.1^{E} (<LOD - 1.7)	4.3^{E} (2.2 - 6.4)	19^{E} (9.4 - 28)	F
6–11	2	512	2.15	5.4^{E} (3.6 - 8.1)	0.97^{E} (0.62 - 1.3)	4.0^{E} (2.0 - 6.1)	F	F
12–19	2	507	1.97	4.4^{E} (2.8 - 6.7)	0.69 (0.45 - 0.93)	3.7^{E} (2.0 - 5.5)	11^{E} (5.2 - 18)	F
20–39	2	352	2.84	4.9 (3.7 - 6.6)	0.91^{E} (0.56 - 1.3)	3.7 (2.5 - 4.9)	14^{E} (5.6 - 23)	F
40–59	2	356	5.06	5.2 (4.1 - 6.6)	0.93 (0.68 - 1.2)	4.7 (3.1 - 6.2)	14^{E} (8.9 - 19)	F
60–79	2	287	4.53	6.5^{E} (4.3 - 10)	0.99^{E} (<LOD - 1.5)	6.0^{E} (3.2 - 8.9)	21^{E} (11 - 31)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 10.2.4

2,5-Dichlorophenol (2,5-DCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1268	3.79	5.1 (4.0 - 6.4)	0.77 (0.53 - 1.0)	4.3 (3.3 - 5.2)	14 (9.5 - 18)	F
Males, 6–11	2	260	2.69	6.1^{E} (3.2 - 12)	1.0^{E} (0.60 - 1.4)	F	F	130^{E} (41 - 210)
Males, 12–19	2	253	1.19	4.1^{E} (2.4 - 7.0)	0.65 (<LOD - 0.83)	3.4^{E} (1.4 - 5.4)	F	84^{E} (41 - 130)
Males, 20–39	2	166	1.20	5.0^{E} (3.4 - 7.5)	0.86^{E} (0.51 - 1.2)	4.2^{E} (2.1 - 6.2)	F	x
Males, 40–59	2	192	4.17	4.8^{E} (3.1 - 7.3)	0.76^{E} (<LOD - 1.1)	4.3 (2.7 - 5.8)	12^{E} (4.5 - 20)	x
Males, 60–79	2	139	2.88	5.4^{E} (3.5 - 8.4)	F	4.6^{E} (2.7 - 6.5)	17^{E} (6.0 - 28)	x
Females, Total 3–79	2	1266	4.34	5.6 (4.3 - 7.2)	1.0 (0.73 - 1.3)	4.3^{E} (2.5 - 6.1)	15^{E} (8.6 - 22)	F
Females, 6–11	2	252	1.59	4.7^{E} (3.3 - 6.9)	0.94^{E} (0.48 - 1.4)	3.9^{E} (2.0 - 5.8)	10^{E} (5.9 - 15)	F
Females, 12–19	2	254	2.76	4.6^{E} (3.1 - 7.1)	0.92^{E} (0.58 - 1.3)	3.9^{E} (2.1 - 5.8)	11^{E} (4.2 - 19)	42^{E} (17 - 67)
Females, 20–39	2	186	4.30	4.8^{E} (3.3 - 7.0)	1.0^{E} (0.37 - 1.7)	3.5^{E} (2.2 - 4.8)	F	x
Females, 40–59	2	164	6.10	5.7 (4.1 - 8.0)	0.95 (0.68 - 1.2)	5.7^{E} (2.9 - 8.5)	F	x
Females, 60–79	2	148	6.08	7.7^{E} (3.8 - 16)	F	7.0^{E} (3.2 - 11)	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

10.3 2,4,5-TRICHLOROPHENOL (2,4,5-TCP)

■ Table 10.3.1

2,4,5-Trichlorophenol (2,4,5-TCP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2560	97.46	—	<LOD	<LOD	<LOD	<LOD
3–5	2	524	97.14	—	<LOD	<LOD	<LOD	<LOD
6–11	2	516	98.06	—	<LOD	<LOD	<LOD	<LOD
12–19	2	512	98.05	—	<LOD	<LOD	<LOD	<LOD
20–39	2	357	97.48	—	<LOD	<LOD	<LOD	<LOD
40–59	2	360	97.78	—	<LOD	<LOD	<LOD	<LOD
60–79	2	291	95.53	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

■ Table 10.3.2

2,4,5-Trichlorophenol (2,4,5-TCP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1281	97.50	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	262	98.09	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	256	97.66	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	167	99.40	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	194	97.42	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	95.77	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1279	97.42	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	254	98.03	—	<LOD	<LOD	<LOD	F
Females, 12–19	2	256	98.44	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	190	95.79	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	166	98.19	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	149	95.30	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 10.3.3

2,4,5-Trichlorophenol (2,4,5-TCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2550	97.84	—	<LOD	<LOD	<LOD	<LOD
3–5	2	523	97.32	—	<LOD	<LOD	<LOD	<LOD
6–11	2	514	98.44	—	<LOD	<LOD	<LOD	<LOD
12–19	2	510	98.43	—	<LOD	<LOD	<LOD	<LOD
20–39	2	355	98.03	—	<LOD	<LOD	<LOD	<LOD
40–59	2	358	98.32	—	<LOD	<LOD	<LOD	<LOD
60–79	2	290	95.86	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 10.3.4

2,4,5-Trichlorophenol (2,4,5-TCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1277	97.81	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	261	98.47	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	98.04	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	166	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	194	97.42	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	95.77	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1273	97.88	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	253	98.42	—	<LOD	<LOD	<LOD	<LOD (<LOD - 1.1)
Females, 12–19	2	255	98.82	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	96.30	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	164	99.39	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	148	95.95	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

10.4 2,4,6-TRICHLOROPHENOL (2,4,6-TCP)

Table 10.4.1

2,4,6-Trichlorophenol (2,4,6-TCP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2559	93.98	—	<LOD	<LOD	<LOD	<LOD
3–5	2	524	93.89	—	<LOD	<LOD	<LOD	<LOD[E] (<LOD - 1.3)
6–11	2	515	93.79	—	<LOD	<LOD	<LOD	<LOD
12–19	2	512	91.99	—	<LOD	<LOD	<LOD	F
20–39	2	357	96.36	—	<LOD	<LOD	<LOD	<LOD
40–59	2	360	96.11	—	<LOD	<LOD	<LOD	<LOD
60–79	2	291	92.44	—	<LOD	<LOD	<LOD	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 10.4.2

2,4,6-Trichlorophenol (2,4,6-TCP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1281	94.46	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	262	94.66	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	256	92.97	—	<LOD	<LOD	<LOD	F
Males, 20–39	2	167	97.01	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	194	94.85	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	93.66	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1278	93.51	—	<LOD	<LOD	<LOD	F
Females, 6–11	2	253	92.89	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	256	91.02	—	<LOD	<LOD	<LOD	F
Females, 20–39	2	190	95.79	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	166	97.59	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	149	91.28	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 10.4.3

2,4,6-Trichlorophenol (2,4,6-TCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2549	94.35	—	<LOD	<LOD	<LOD	<LOD
3–5	2	523	94.07	—	<LOD	<LOD	<LOD	<LOD (<LOD - 4.1)
6–11	2	513	94.15	—	<LOD	<LOD	<LOD	<LOD
12–19	2	510	92.35	—	<LOD	<LOD	<LOD	<LOD (<LOD - 2.1)
20–39	2	355	96.90	—	<LOD	<LOD	<LOD	<LOD
40–59	2	358	96.65	—	<LOD	<LOD	<LOD	<LOD
60–79	2	290	92.76	—	<LOD	<LOD	<LOD	2.8 (<LOD - 3.6)

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 10.4.4

2,4,6-Trichlorophenol (2,4,6-TCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1277	94.75	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	261	95.02	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	93.33	—	<LOD	<LOD	<LOD	<LOD (<LOD - 1.7)
Males, 20–39	2	166	97.59	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	194	94.85	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	93.66	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1272	93.95	—	<LOD	<LOD	<LOD	<LOD (<LOD - 3.3)
Females, 6–11	2	252	93.25	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	255	91.37	—	<LOD	<LOD	<LOD	<LOD (<LOD - 2.5)
Females, 20–39	2	189	96.30	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	164	98.78	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	148	91.89	—	<LOD	<LOD	<LOD	x

[a] Breakdown by sex for the 3–5 year old age group is not recommended.

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

10.5 PENTACHLOROPHENOL (PCP)

■ Table 10.5.1

Pentachlorophenol (PCP) — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2551	96.55	—	<LOD	<LOD	<LOD	<LOD
3–5	2	524	96.37	—	<LOD	<LOD	<LOD	<LOD
6–11	2	513	97.66	—	<LOD	<LOD	<LOD	<LOD
12–19	2	512	96.29	—	<LOD	<LOD	<LOD	<LOD
20–39	2	354	97.18	—	<LOD	<LOD	<LOD	<LOD
40–59	2	359	97.77	—	<LOD	<LOD	<LOD	<LOD
60–79	2	289	93.08	—	<LOD	<LOD	<LOD	0.71[E] (<LOD - 1.1)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

■ Table 10.5.2

Pentachlorophenol (PCP) — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1276	96.32	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	260	97.69	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	256	94.92	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	164	98.17	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	194	97.42	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	94.37	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1275	96.78	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	253	97.63	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	256	97.66	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	190	96.32	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	165	98.18	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	147	91.84	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 10.5.3

Pentachlorophenol (PCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2541	96.93	—	<LOD	<LOD	<LOD	<LOD
3–5	2	523	96.56	—	<LOD	<LOD	<LOD	<LOD
6–11	2	511	98.04	—	<LOD	<LOD	<LOD	<LOD
12–19	2	510	96.67	—	<LOD	<LOD	<LOD	<LOD
20–39	2	352	97.73	—	<LOD	<LOD	<LOD	<LOD
40–59	2	357	98.32	—	<LOD	<LOD	<LOD	<LOD
60–79	2	288	93.40	—	<LOD	<LOD	<LOD	1.7 (<LOD - 2.2)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 10.5.4

Pentachlorophenol (PCP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1272	96.62	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	259	98.07	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	95.29	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	163	98.77	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	194	97.42	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	94.37	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1269	97.24	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	252	98.02	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	255	98.04	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	96.83	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	163	99.39	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	146	92.47	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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ENVIRONMENTAL PHENOL AND TRICLOCARBAN SUMMARIES AND RESULTS

11

11.1 BISPHENOL A

Bisphenol A (BPA; CASRN 80-05-7) is a synthetic chemical used as a monomer in the production of some polycarbonate plastics and as a precursor for monomers of certain epoxy-phenolic resins (EFSA, 2007). Polycarbonate is used in the manufacture of food and beverage containers such as repeat-use water bottles and storage containers; it was also historically used in infant bottles. Epoxy resins are used as an interior protective lining for food and beverage cans. Additional end-use products containing polycarbonate plastics and resins include medical devices, some dental fillings and sealants, sporting and safety equipment, electronics, and automotive parts (EFSA, 2007; NTP, 2007). BPA is also used in the paper industry to produce thermal paper used for various products including receipts, prescription labels, airline tickets, and lottery tickets (Geens et al., 2011).

BPA does not occur naturally in the environment (Environment Canada & Health Canada, 2008a). Entry into the environment may occur from industrial sources or from product leaching, disposal, and use (CDC, 2009).

The primary route of exposure to BPA for the general public is through dietary intake as a result of various sources including migration from food packaging and repeat-use polycarbonate containers (Health Canada, 2008). Health Canada has recently updated its dietary exposure estimates for BPA following the completion of a number of specific food surveys, including canned foods and beverages, liquid infant formula and Total Diet samples (Health Canada, 2012). Exposure can also occur from contact with environmental media, including ambient and indoor air, drinking water, soil, and dust, and from the use of consumer products (Environment Canada & Health Canada, 2008a). BPA exposure from dental fillings and sealants is short term and considered unlikely to contribute substantially to chronic exposure (WHO, 2011).

In humans, dietary BPA is readily absorbed and undergoes extensive metabolism in the gut wall and the liver (WHO, 2011). Recent studies have also suggested that it may be absorbed and metabolized by the skin following dermal exposure to free BPA in products such as those made from thermal printing papers (Mielke et al., 2011; Zalko et al., 2011). Glucuronidation has been recognized as a major metabolic pathway for BPA, resulting in the BPA-glucuronide conjugate metabolite (EFSA, 2008; FDA, 2008). Conjugation of BPA to BPA-sulphate is shown to be a minor metabolic pathway (Dekant & Völkel, 2008). The BPA-glucuronide metabolite is rapidly excreted in urine with a half-life of less than 2 hours (WHO, 2011). Urinary levels of total BPA, including both conjugated and free unconjugated forms, are commonly used as biomarkers to assess recent exposures (Ye et al., 2005).

Characterization of the potential risk to human health from exposure to BPA includes key effects on the liver and on reproduction, including fertility and developmental effects (EU, 2010; Environment Canada & Health Canada, 2008a). Developmental neurotoxicity studies in animals have suggested that at low levels of exposure in fetuses and newborns, BPA can affect neural development and behaviour (Environment

Canada & Health Canada, 2008a; WHO, 2011). Health Canada concluded that there appeared to be sufficient evidence to describe BPA as an endocrine disrupter (Health Canada, 2008). The potential role of BPA and other environmental estrogens in the prevalence of obesity and related metabolic diseases, as well as certain types of cancer, is under intensive debate and investigation among scientific communities (Ben-Jonathan et al., 2009; Carwile & Michels, 2011; Newbold et al., 2009; Soto et al., 2008).

The Government of Canada has conducted a scientific screening assessment of the impact of human and environmental exposure to BPA and determined that it is toxic to human health and the environment as per the criteria set out under the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; Canada, 2010). Because of the uncertainty raised in some laboratory animal studies relating to the potential effects of low levels of BPA, a precautionary approach was applied when characterizing risk. Combining the highest potential exposure and potential vulnerability, the risk management strategy for health focused on decreasing exposure to newborns and infants (Environment Canada & Health Canada, 2008b). As of March 2010, under the *Canada Consumer Product Safety Act*, Health Canada has prohibited the manufacturing, advertisement, sale, or import of polycarbonate baby bottles that contain BPA (Canada, 2010). This precautionary measure protects newborns and infants up to 18 months old (Canada, 2010).

Health Canada is also committed to supporting industry in developing a Code of Practice to reduce levels of BPA in infant-formula can linings (Health Canada, 2010). Health Canada, the United States Food and Drug Administration, and industry have met to initiate this process. Health Canada has committed to facilitating the assessment of proposed industry alternatives to BPA for use in infant-formula and other can coatings, as well as setting stringent migration targets for BPA in infant-formula cans (Health Canada, 2010). Migration targets for canned foods, in general, will be explored. Health Canada will continue to review pre-market submissions for infant-formula packaging to ensure the lowest levels of BPA achievable (Health Canada, 2010). BPA is also included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011). Risk management actions have also been developed under CEPA 1999 with the objective of minimizing releases of BPA in industrial effluents (Canada, 2012).

A provisional tolerable daily intake for BPA, based solely on dietary exposure through food packaging, was established by Health Canada in 1996 and reaffirmed for the general population in 2008 (Health Canada, 2008).

Urinary total BPA (including both free and conjugated forms) was measured in the urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented as both µg/L (Tables 11.1.1, 11.1.2, and 11.1.3) and µg/g creatinine (Tables 11.1.4, 11.1.5, and 11.1.6). Finding a measurable amount of BPA in urine is an indicator of exposure to BPA and does not necessarily mean that an adverse health effect will occur.

Table 11.1.1

Bisphenol A (BPA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5476	9.26	1.2 (1.1 - 1.2)	F	1.3 (1.1 - 1.4)	2.5 (2.2 - 2.8)	6.9 (5.6 - 8.2)
Total, 6–79	2	2036	5.26	1.2 (1.1 - 1.3)	0.27 (0.22 - 0.31)	1.2 (1.1 - 1.3)	2.4 (2.1 - 2.6)	6.7 (4.8 - 8.5)
Males, Total 6–79	1	2659	7.67	1.3 (1.2 - 1.4)	0.23^E (<LOD - 0.34)	1.4 (1.2 - 1.6)	2.6 (2.3 - [illegible])	6.7 (5.3 - 8.1)
Males, Total 6–79	2	1021	4.90	1.3 (1.1 - 1.4)	0.27^E (<LOD - 0.37)	1.3 (1.1 - 1.5)	2.[illegible] (2.1 - 2.8)	7.3^E (4.0 - 11)
Females, Total 6–79	1	2817	10.76	1.0 (0.93 - 1.2)	<LOD	1.1 (0.94 - 1.3)	2.4 (2.0 - 2.7)	7.0 (5.3 - 8.6)
Females, Total 6–79	2	1015	5.62	1.2 (1.0 - 1.3)	0.26 (0.21 - 0.32)	1.1 (0.98 - 1.3)	2.3 (1.9 - 2.7)	6.6 (4.8 - 8.4)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 11.1.2

Bisphenol A (BPA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2560	5.04	1.2 (1.1 - 1.3)	0.27 (0.22 - 0.31)	1.2 (1.1 - 1.3)	2.4 (2.1 - 2.6)	6.7 (4.8 - 8.6)
3–5[b]	1							
3–5	2	524	4.20	1.4 (1.1 - 1.8)	0.30^E (<LOD - 0.46)	1.3 (1.1 - 1.5)	2.6 (1.8 - 3.4)	9.9^E (5.5 - 14)
6–11	1	1031	6.79	1.3 (1.2 - 1.4)	0.28 (<LOD - 0.37)	1.3 (1.1 - 1.6)	2.6 (2.2 - 3.0)	7.1 (5.5 - 8.7)
6–11	2	516	5.81	1.4 (1.1 - 1.7)	0.25^E (<LOD - 0.41)	1.3 (0.94 - 1.7)	2.3 (1.6 - 3.0)	F
12–19	1	980	6.22	1.5 (1.3 - 1.8)	0.29 (0.22 - 0.36)	1.6 (1.3 - 1.9)	3.0 (2.3 - 3.7)	8.3 (6.2 - 10)
12–19	2	512	4.69	1.3 (1.1 - 1.6)	0.35 (0.23 - 0.47)	1.3 (0.99 - 1.6)	2.5 (2.0 - 2.9)	7.6^E (4.3 - 11)
20–39	1	1165	8.84	1.3 (1.2 - 1.5)	F	1.4 (1.2 - 1.6)	2.8 (2.5 - 3.1)	7.3 (5.2 - 9.5)
20–39	2	357	2.80	1.3 (1.1 - 1.5)	0.32 (0.21 - 0.42)	1.3 (0.92 - 1.6)	2.4 (1.8 - 3.1)	F
40–59	1	1219	12.06	1.0 (0.96 - 1.1)	<LOD	1.2 (1.1 - 1.4)	2.4 (2.0 - 2.8)	6.6 (4.8 - 8.4)
40–59	2	360	6.11	1.2 (0.97 - 1.5)	0.25^E (<LOD - 0.37)	1.2 (0.98 - 1.4)	2.2 (1.7 - 2.7)	6.7^E (2.6 - 11)
60–79	1	1081	11.66	0.90 (0.81 - 0.99)	<LOD	0.99 (0.87 - 1.1)	1.8 (1.5 - 2.2)	5.2 (3.8 - 6.6)
60–79	2	291	7.22	1.0 (0.83 - 1.3)	0.21^E (<LOD - 0.31)	0.99 (0.76 - 1.2)	2.3 (1.5 - 3.1)	6.3 (4.4 - 8.1)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 11.1.3

Bisphenol A (BPA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1281	4.84	1.3 (1.1 - 1.5)	0.27 (<LOD - 0.36)	1.3 (1.1 - 1.5)	2.5 (2.2 - 2.8)	7.9^{E} (4.3 - 11)
Males, 6–11	1	524	6.11	1.3 (1.1 - 1.5)	0.32 (0.22 - 0.41)	1.3 (1.1 - 1.6)	2.5 (2.1 - 2.9)	6.8 (4.6 - 8.9)
Males, 6–11	2	262	7.25	1.3 (1.0 - 1.8)	F	1.4^{E} (0.86 - 1.9)	2.3^{E} (1.1 - 3.5)	5.5^{E} (2.1 - 8.8)
Males, 12–19	1	504	5.56	1.4 (1.2 - 1.8)	0.34^{E} (<LOD - 0.50)	1.5 (1.2 - 1.9)	2.7 (2.1 - 3.3)	8.2 (5.6 - 11)
Males, 12–19	2	256	4.69	1.5 (1.1 - 2.0)	0.46^{E} (0.25 - 0.67)	1.4 (1.0 - 1.7)	2.6^{E} (1.4 - 3.8)	7.9^{E} (4.6 - 11)
Males, 20–39	1	513	7.60	1.4 (1.2 - 1.6)	0.27^{E} (<LOD - 0.45)	1.5 (1.2 - 1.8)	2.9 (2.5 - 3.2)	6.6 (5.0 - 8.1)
Males, 20–39	2	167	2.99	1.4 (0.98 - 1.9)	F	1.4 (1.1 - 1.8)	2.5^{E} (1.4 - 3.7)	x
Males, 40–59	1	577	9.01	1.2 (1.1 - 1.4)	F	1.4 (1.2 - 1.6)	2.6 (2.1 - 3.0)	6.4 (4.3 - 8.6)
Males, 40–59	2	194	3.61	1.2 (0.94 - 1.6)	F	1.2 (0.91 - 1.6)	2.3 (1.6 - 3.0)	x
Males, 60–79	1	541	9.80	1.1 (0.94 - 1.2)	F	1.2 (1.0 - 1.4)	2.1 (1.8 - 2.5)	5.9 (4.0 - 7.8)
Males, 60–79	2	142	4.93	1.1 (0.83 - 1.5)	0.25^{E} (<LOD - 0.40)	1.1^{E} (0.67 - 1.5)	2.4 (1.8 - 3.1)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1279	5.24	1.2 (1.0 - 1.3)	0.26 (0.21 - 0.32)	1.1 (0.98 - 1.3)	2.3 (2.0 - 2.7)	6.6 (4.9 - 8.4)
Females, 6–11	1	507	7.50	1.3 (1.1 - 1.6)	0.25^{E} (<LOD - 0.36)	1.4 (0.99 - 1.7)	2.7 (2.1 - 3.4)	7.6 (5.4 - 9.7)
Females, 6–11	2	254	4.33	1.4 (1.0 - 1.8)	F	1.3 (0.87 - 1.6)	2.2^{E} (1.3 - 3.1)	F
Females, 12–19	1	476	6.93	1.6 (1.3 - 1.9)	0.26^{E} (<LOD - 0.37)	1.8 (1.4 - 2.1)	3.8 (3.1 - 4.5)	8.1 (5.5 - 11)
Females, 12–19	2	256	4.69	1.2 (0.98 - 1.5)	0.31^{E} (<LOD - 0.46)	1.2 (0.85 - 1.5)	2.4 (1.8 - 3.0)	4.3^{E} (2.6 - 6.1)
Females, 20–39	1	652	9.82	1.3 (1.1 - 1.5)	F	1.4 (1.1 - 1.6)	2.7 (2.1 - 3.2)	8.1^{E} (5.0 - 11)
Females, 20–39	2	190	2.63	1.2 (0.99 - 1.5)	0.33^{E} (0.20 - 0.46)	1.1^{E} (0.69 - 1.6)	2.4 (1.7 - 3.1)	x
Females, 40–59	1	642	14.80	0.86 (0.76 - 0.96)	<LOD	0.99 (0.86 - 1.1)	2.0 (1.5 - 2.5)	6.6 (4.7 - 8.6)
Females, 40–59	2	166	9.04	1.2^{E} (0.81 - 1.7)	F	1.2 (0.79 - 1.5)	2.0^{E} (1.2 - 2.8)	x
Females, 60–79	1	540	13.52	0.76 (0.65 - 0.88)	<LOD	0.78 (0.59 - 0.98)	1.6 (1.3 - 1.9)	4.8 (3.5 - 6.2)
Females, 60–79	2	149	9.40	0.98 (0.70 - 1.4)	<LOD	0.98 (0.66 - 1.3)	2.2^{E} (1.1 - 3.4)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 11.1.4

Bisphenol A (BPA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5462	9.28	1.4 (1.3 - 1.5)	<LOD (<LOD - 0.49)	1.3 (1.2 - 1.5)	2.5 (2.2 - 2.7)	7.2 (6.4 - 8.0)
Total, 6–79	2	2027	5.28	1.2 (1.1 - 1.3)	0.40 (0.33 - 0.46)	1.1 (1.0 - 1.2)	2.0 (1.8 - 2.2)	6.7 (4.9 - 8.5)
Males, Total 6–79	1	2650	7.70	1.3 (1.2 - 1.4)	0.40 (<LOD - 0.49)	1.2 (1.1 - 1.4)	2.2 (1.9 - 2.5)	6.0 (5.3 - 6.8)
Males, Total 6–79	2	1018	4.91	1.1 (0.94 - 1.2)	0.36 (<LOD - 0.44)	1.0 (0.88 - 1.2)	1.7 (1.6 - 1.9)	5.8[E] (3.4 - 8.2)
Females, Total 6–79	1	2812	10.78	1.5 (1.4 - 1.6)	<LOD	1.5 (1.3 - 1.6)	2.7 (2.4 - 3.1)	8.5 (7.0 - 10)
Females, Total 6–79	2	1009	5.65	1.3 (1.2 - 1.4)	0.46 (0.41 - 0.52)	1.3 (1.1 - 1.4)	2.2 (1.9 - 2.5)	6.9 (4.4 - 9.3)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 11.1.5

Bisphenol A (BPA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2550	5.06	1.2 (1.1 - 1.3)	0.40 (0.34 - 0.46)	1.2 (1.1 - 1.3)	2.1 (1.9 - 2.3)	6.9 (5.1 - 8.7)
3–5[b]	1							
3–5	2	523	4.21	2.5 (1.9 - 3.1)	0.88[E] (<LOD - 1.2)	2.2 (1.9 - 2.4)	3.9 (2.8 - 5.0)	13 (9.2 - 18)
6–11	1	1028	6.81	2.0 (1.8 - 2.2)	0.65 (<LOD - 0.75)	1.9 (1.6 - 2.2)	3.5 (2.9 - 4.1)	9.8 (7.4 - 12)
6–11	2	514	5.84	1.6 (1.3 - 1.9)	0.45[E] (<LOD - 0.66)	1.5 (1.2 - 1.7)	2.5 (1.9 - 3.1)	11[E] (3.4 - 18)
12–19	1	978	6.24	1.3 (1.2 - 1.5)	0.41 (0.34 - 0.49)	1.2 (1.0 - 1.4)	2.3 (1.9 - 2.7)	6.4[E] (4.0 - 8.8)
12–19	2	510	4.71	1.0 (0.84 - 1.2)	0.32[E] (0.20 - 0.44)	0.94 (0.78 - 1.1)	1.7 (1.4 - 2.0)	5.0 (3.8 - 6.3)
20–39	1	1161	8.87	1.5 (1.4 - 1.6)	0.44 (<LOD - 0.54)	1.4 (1.3 - 1.6)	2.6 (2.3 - 2.8)	6.8 (5.9 - 7.7)
20–39	2	355	2.82	1.1 (0.90 - 1.4)	0.40 (0.28 - 0.51)	1.1 (0.78 - 1.3)	1.9 (1.5 - 2.2)	F
40–59	1	1214	12.11	1.3 (1.2 - 1.5)	<LOD	1.3 (1.2 - 1.4)	2.3 (1.9 - 2.7)	7.5 (6.1 - 8.8)
40–59	2	358	6.15	1.2 (0.99 - 1.5)	0.43 (<LOD - 0.55)	1.1 (0.91 - 1.3)	1.9 (1.4 - 2.5)	6.9[E] (3.3 - 10)
60–79	1	1081	11.66	1.3 (1.1 - 1.4)	<LOD	1.2 (1.1 - 1.3)	2.2 (1.8 - 2.6)	7.6 (5.4 - 9.8)
60–79	2	290	7.24	1.2 (1.0 - 1.5)	0.34[E] (<LOD - 0.50)	1.2 (0.98 - 1.3)	2.2 (1.7 - 2.8)	6.9[E] (3.1 - 11)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 11.1.6

Bisphenol A (BPA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1277	4.86	1.1 (0.97 - 1.2)	0.36 (<LOD - 0.45)	1.1 (0.92 - 1.2)	1.8 (1.6 - 2.0)	6.2[E] (3.5 - 8.8)
Males, 6–11	1	522	6.13	1.9 (1.7 - 2.1)	0.63 (0.48 - 0.78)	1.9 (1.6 - 2.3)	3.3 (2.7 - 3.8)	7.8 (5.6 - 10)
Males, 6–11	2	261	7.28	1.5 (1.2 - 2.0)	0.47[E] (<LOD - 0.69)	1.5 (1.1 - 1.8)	2.5[E] (1.3 - 3.7)	7.8[E] (3.7 - 12)
Males, 12–19	1	503	5.57	1.2 (1.0 - 1.4)	0.41 (<LOD - 0.48)	1.1 (0.97 - 1.3)	2.1 (1.5 - 2.7)	5.7[E] (2.6 - 8.9)
Males, 12–19	2	255	4.71	1.0 (0.79 - 1.4)	0.32[E] (0.16 - 0.48)	0.98 (0.78 - 1.2)	1.8 (1.2 - 2.4)	4.9[E] (3.1 - 6.7)
Males, 20–39	1	511	7.63	1.3 (1.2 - 1.4)	0.43 (<LOD - 0.52)	1.3 (1.0 - 1.5)	2.2 (1.8 - 2.7)	5.1 (4.1 - 6.0)
Males, 20–39	2	166	3.01	0.99 (0.75 - 1.3)	0.37 (<LOD - 0.49)	0.89 (0.66 - 1.1)	1.6 (1.1 - 2.0)	x
Males, 40–59	1	573	9.08	1.2 (1.1 - 1.4)	<LOD (<LOD - 0.50)	1.2 (1.1 - 1.4)	2.1 (1.6 - 2.6)	6.1 (4.5 - 7.7)
Males, 40–59	2	194	3.61	1.0 (0.87 - 1.2)	0.35[E] (<LOD - 0.48)	1.0 (0.76 - 1.3)	1.7 (1.4 - 2.0)	x
Males, 60–79	1	541	9.80	1.1 (1.0 - 1.3)	<LOD (<LOD - 0.43)	1.2 (1.0 - 1.3)	2.0 (1.8 - 2.3)	5.9 (4.4 - 7.4)
Males, 60–79	2	142	4.93	1.0 (0.78 - 1.4)	0.25[E] (<LOD - 0.43)	1.1 (0.80 - 1.4)	2.0 (1.4 - 2.5)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1273	5.26	1.3 (1.2 - 1.5)	0.47 (0.42 - 0.52)	1.3 (1.2 - 1.4)	2.3 (1.9 - 2.6)	6.9[E] (4.4 - 9.5)
Females, 6–11	1	506	7.51	2.1 (1.8 - 2.4)	0.65 (<LOD - 0.79)	1.9 (1.5 - 2.2)	3.7 (2.9 - 4.6)	12[E] (6.1 - 17)
Females, 6–11	2	253	4.35	1.6 (1.2 - 2.0)	<LOD (<LOD - 0.66)	1.5 (1.3 - 1.7)	2.6 (1.8 - 3.4)	F
Females, 12–19	1	475	6.95	1.4 (1.3 - 1.6)	0.45 (<LOD - 0.54)	1.4 (1.2 - 1.6)	2.4 (2.0 - 2.8)	6.7[E] (2.1 - 11)
Females, 12–19	2	255	4.71	0.99 (0.83 - 1.2)	0.32[E] (<LOD - 0.44)	0.88 (0.72 - 1.0)	1.6 (1.4 - 1.9)	4.9 (3.7 - 6.2)
Females, 20–39	1	650	9.85	1.7 (1.5 - 1.9)	0.50 (<LOD - 0.63)	1.5 (1.2 - 1.9)	2.9 (2.5 - 3.2)	7.8 (5.8 - 9.8)
Females, 20–39	2	189	2.65	1.2 (0.89 - 1.7)	0.51 (0.33 - 0.69)	1.3 (0.90 - 1.7)	2.1 (1.7 - 2.5)	x
Females, 40–59	1	641	14.82	1.4 (1.3 - 1.6)	<LOD	1.4 (1.2 - 1.5)	2.7 (2.0 - 3.4)	8.8 (5.6 - 12)
Females, 40–59	2	164	9.15	1.4 (1.1 - 1.8)	0.46 (<LOD - 0.58)	1.3 (1.1 - 1.6)	2.5 (1.7 - 3.3)	x
Females, 60–79	1	540	13.52	1.4 (1.2 - 1.6)	<LOD	1.3 (1.2 - 1.5)	2.4 (1.7 - 3.1)	8.9[E] (5.1 - 13)
Females, 60–79	2	148	9.46	1.4 (1.0 - 1.8)	<LOD	1.2 (0.85 - 1.5)	2.6[E] (1.4 - 3.9)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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11.2 TRICLOCARBAN

Triclocarban (CASRN 101-20-2) is a high-production volume synthetic chemical that has been used as an antibacterial agent since the late 1950s (SCCP, 2005). It is used in various consumer and personal-care products including bar and liquid soaps, body washes, toothpastes, deodorants, detergents, and wipes (TCC, 2002; Ye et al., 2011). As of August 2012, no drug products are marketed in Canada with triclocarban as an active medicinal ingredient nor is it an ingredient in any licensed natural health products (Health Canada, 2012a; Health Canada, 2012b).

Triclocarban is not naturally found in the environment. It may be found in surface water owing to the widespread use of triclocarban-containing products and related releases to waste-water systems (Schebb et al., 2011; Ye et al., 2011).

The major route of exposure for the general public is dermal contact with personal-care products containing triclocarban (TCC, 2002). Indirect exposure to triclocarban from ingestion of food or water is expected to be minimal (TCC, 2002).

Following dermal exposure, fairly poor absorption of triclocarban has been observed in humans ranging from less than 1% to 7% (Scharpf Jr. & Hill, 1975; Schebb et al., 2011; Wester et al., 1985). Human metabolism of triclocarban involves either direct glucuronidation or hydroxylation followed by conjugation with glururonic or sulphuric acid (Hiles & Birch, 1978). The majority of triclocarban is excreted in the feces in its conjugated form within 5 days whereas a smaller amount (primarily in conjugated forms) is excreted in the urine within 80 hours (Ahn et al., 2011; Hiles & Birch, 1978; Jeffcoat et al., 1977; Ye et al., 2011). It has been suggested that the level of total triclocarban (conjugated and free) in urine may serve as a biomarker for human exposure (Ye et al., 2011).

In humans, triclocarban has been shown to be minimally irritating to skin and does not display sensitization potential (Maibach et al., 1978; SCCP, 2005). There is some evidence suggesting that it may impair mammalian reproduction by reducing birth weight and survival rate in rats (Nolen & Dierckman, 1979; SCCP, 2005). In some studies at high concentrations, triclocarban has been reported to cause endocrine-modulating effects in rats and in cell-based tests (Ahn et al., 2008; Duleba et al., 2011). A carcinogenicity study in rats demonstrated no evidence of a dose-related increase in tumor incidence at any site (TCC, 2002). To date, triclocarban has not been assessed for carcinogenic potential by the International Agency for Research on Cancer.

As part of the Chemicals Management Plan under the *Canadian Environmental Protection Act, 1999*, triclocarban was categorized as a priority substance for future assessment based on environmental criteria but not human health (Canada, 1999; Environment Canada, 2011). In 2005, the European Union Scientific Committee on Consumer Products concluded that the use of triclocarban up to a maximum concentration of 1.5% for non-preservative purposes in cosmetic rinse-off hand and body care products does not pose a direct risk to the health of the consumer (SCCP, 2005).

Triclocarban was measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and is presented as both µg/L and µg/g creatinine (Tables 11.2.1, 11.2.2, 11.2.3, and 11.2.4). Finding a measurable amount of triclocarban in urine is an indicator of exposure to triclocarban and does not necessarily mean that an adverse health effect will occur. These data provide baseline urinary levels for triclocarban in the Canadian population.

Table 11.2.1

Triclocarban — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2549	96.23	—	<LOD	<LOD	<LOD	<LOD
3–5	2	524	97.90	—	<LOD	<LOD	<LOD	<LOD
6–11	2	515	97.09	—	<LOD	<LOD	<LOD	<LOD
12–19	2	507	96.06	—	<LOD	<LOD	<LOD	<LOD
20–39	2	356	97.19	—	<LOD	<LOD	<LOD	<LOD
40–59	2	359	93.31	—	<LOD	<LOD	<LOD	F
60–79	2	288	94.44	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

F Data is too unreliable to be published.

Table 11.2.2

Triclocarban — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1276	95.85	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	262	96.95	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	253	96.05	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	167	97.60	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	92.75	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	141	92.91	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1273	96.62	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	253	97.23	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	254	96.06	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	96.83	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	166	93.98	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	147	95.92	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 11.2.3

Triclocarban (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2539	96.61	—	<LOD	<LOD	<LOD	<LOD
3–5	2	523	98.09	—	<LOD	<LOD	<LOD	<LOD
6–11	2	513	97.47	—	<LOD	<LOD	<LOD	<LOD
12–19	2	505	96.44	—	<LOD	<LOD	<LOD	<LOD
20–39	2	354	97.74	—	<LOD	<LOD	<LOD	<LOD
40–59	2	357	93.84	—	<LOD	<LOD	<LOD	F
60–79	2	287	94.77	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

F Data is too unreliable to be published.

Table 11.2.4

Triclocarban (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1272	96.15	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	261	97.32	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	252	96.43	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	166	98.19	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	92.75	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	141	92.91	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1267	97.08	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	252	97.62	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	253	96.44	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	188	97.34	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	164	95.12	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	146	96.58	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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11.3 TRICLOSAN

Triclosan (CASRN 3380-34-5) is a synthetic chemical with wide application as an antimicrobial agent and as a preservative since 1972 (Jones et al., 2000). It is used as a medicinal ingredient in non-prescription drug products and as a non-medicinal ingredient in cosmetics, natural health products, and drug products. In 2011, approximately 1,600 cosmetic and natural health products containing triclosan were reported to be in commerce in Canada (Environment Canada & Health Canada, 2012a). These products include face cream, face and eye makeup, hand cream, deodorant sticks and sprays, fragrances, body lotion, tanning products, skin cleansers, shaving preparations, and shampoos. As of August 2012, an additional 131 products containing triclosan as an active medicinal ingredient are regulated as non-prescription drug products in Canada, including toothpastes, skin cleansers, and moisturizers (Health Canada, 2012a). Triclosan is also used to control the spread of bacteria in household items such as cleaners, textiles, carpets, and cutting boards, and medical devices (Jones et al., 2000). As a material preservative, triclosan is registered under the *Pest Control Products Act* (Canada, 2006); no domestic class pest-control products containing triclosan are currently registered for use in Canada (Environment Canada & Health Canada, 2012b).

Triclosan does not occur naturally in the environment (Environment Canada & Health Canada, 2012a). Use of triclosan-containing products results in its release to waste-water systems and subsequently surface water (Environment Canada & Health Canada, 2012a). The potential routes of exposure for the general public are oral and dermal contact with products such as toothepastes and cosmetics that contain triclosan, ingestion of drinking water or breast milk, and ingestion of household dust (Environment Canada & Health Canada, 2012b).

Following oral exposures, triclosan is rapidly absorbed and distributed in humans with plasma levels increasing rapidly within 1 to 4 hours (Environment Canada & Health Canada, 2012b). Absorption following dermal exposure to triclosan-containing products ranges from 11% to 17% in humans (Maibach, 1969; Queckenberg et al., 2010; Stierlin, 1972). Only limited absorption (approximately 5% to 10%) occurs under normal conditions of toothpaste use (SCCP, 2009). Following all routes of administration, absorbed triclosan is nearly totally converted to glucuronic and sulfuric acid conjugates (Fang et al., 2010). Triclosan is rapidly eliminated after metabolism with an observed half-life ranging from 9 to 32 hours (SCCP, 2009). About 24% to 83% of absorbed triclosan is excreted in urine, mostly as the glucuronide conjugate (Fang et al., 2010; Sandborgh-Englund et al., 2006). Excretion of triclosan in feces is as the free unchanged compound and represents a smaller portion of the administered dose (10% to 30%) (Environment Canada & Health Canada, 2012b). Currently, there is no evidence of bioaccumulation potential in humans (SCCP 2009). The concentration of triclosan in urine (conjugated and free) can be used as a biomarker of exposure to triclosan (Calafat et al., 2007).

Triclosan is not acutely toxic to mammals, but it can interact with cellular enzymes and receptors (Calafat et al., 2007). The potential effects of these interactions remain unknown. There have been observations of adverse effects of triclosan on thyroid hormone homeostasis resulting from liver toxicity in rodents; however, the overall weight of evidence does not currently support effects of triclosan on thyroid function as a critical effect for risk characterization in humans (Environment Canada & Health Canada, 2012b). Adverse effects on the liver were selected as the toxicological endpoint of concern in the recent human health evaluation of triclosan (Environment Canada & Health Canada, 2012b). To date, triclosan has not been assessed for carcinogenic potential by the International Agency for Research on Cancer; the United States Environmental Protection Agency has classified triclosan as not likely to be carcinogenic to humans (EPA, 2008).

Health Canada and Environment Canada have jointly reviewed triclosan in a preliminary risk assessment and have proposed that it is not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health (Environment Canada & Health Canada, 2012b). In the same assessment, Health Canada's Pest Management Regulatory Agency has proposed that the use of pest control products containing triclosan in Canada does not pose an unacceptable risk to human health (Environment Canada & Health Canada, 2012b). However, at current environmental levels, it is proposed that triclosan is an ecological concern and therefore it meets the definition of toxic as set out under section 64 of the *Canadian Environmental Protection Act, 1999* (Canada, 1999).

Triclosan is included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011). The cosmetic ingredient hotlist indicates concentration limits of triclosan in mouthwash and other cosmetic products for dental and topical use (Environment Canada & Health Canada, 2012b; Health Canada, 2012b). In addition, the cosmetic ingredient hotlist indicates that oral cosmetic products containing triclosan shall include a label statement indicating that the product is not to be used by children under 12 years of age (Health Canada, 2011). The hotlist also indicates that mouthwashes include a label statement to the effect of "avoid swallowing" (Health Canada, 2011).

Triclosan was measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and is presented as both μg/L and μg/g creatinine (Tables 11.3.1, 11.3.2, 11.3.3, and 11.3.4). Finding a measurable amount of triclosan in urine is an indicator of exposure to triclosan and does not necessarily mean that an adverse health effect will occur. These data provide baseline urinary levels for triclosan in the Canadian population.

Table 11.3.1

Triclosan — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2550	28.20	16 (13 - 20)	<LOD	9.5^{E} (5.8 - 13)	F	710 (540 - 880)
3–5	2	523	29.45	8.9 (7.3 - 11)	<LOD	7.3 (4.9 - 9.6)	20 (16 - 24)	120^{E} (68 - 160)
6–11	2	515	33.98	8.5 (6.7 - 11)	<LOD	3.8^{E} (<LOD - 5.9)	23^{E} (14 - 31)	250^{E} (82 - 410)
12–19	2	510	19.02	20 (14 - 27)	<LOD	13^{E} (7.7 - 18)	F	640^{E} (400 - 870)
20–39	2	353	19.26	21^{E} (13 - 33)	<LOD	17^{E} (9.1 - 25)	F	910^{E} (430 - 1400)
40–59	2	359	28.97	19^{E} (12 - 29)	<LOD	12^{E} (4.3 - 20)	F	740^{E} (290 - 1200)
60–79	2	290	41.72	—	<LOD	4.8^{E} (<LOD - 6.8)	24^{E} (7.3 - 40)	590 (430 - 750)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 11.3.2

Triclosan — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1274	26.77	18 (13 - 26)	<LOD	12^{E} (5.3 - 18)	F	790^{E} (350 - 1200)
Males, 6–11	2	262	34.35	8.8^{E} (5.9 - 13)	<LOD	F	F	F
Males, 12–19	2	254	18.11	20^{E} (13 - 31)	<LOD	12^{E} (7.0 - 18)	F	F
Males, 20–39	2	165	18.18	F	<LOD	F	F	x
Males, 40–59	2	193	25.91	23^{E} (13 - 41)	<LOD	15^{E} (7.3 - 23)	F	x
Males, 60–79	2	141	36.88	14^{E} (8.0 - 24)	<LOD	F	F	x
Females, Total 3–79	2	1276	29.62	14 (11 - 18)	<LOD	7.5^{E} (3.1 - 12)	F	680^{E} (410 - 960)
Females, 6–11	2	253	33.60	8.2^{E} (5.6 - 12)	<LOD	F	22^{E} (10 - 34)	F
Females, 12–19	2	256	19.92	19^{E} (13 - 29)	<LOD	14^{E} (4.9 - 23)	F	620^{E} (370 - 870)
Females, 20–39	2	188	20.21	19^{E} (11 - 35)	<LOD	16^{E} (6.0 - 27)	F	x
Females, 40–59	2	166	32.53	16^{E} (8.4 - 29)	<LOD	F	F	x
Females, 60–79	2	149	46.31	—	<LOD	F	14^{E} (4.4 - 23)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 11.3.3

Triclosan (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2540	28.31	15 (12 - 19)	<LOD	9.4 (7.2 - 12)	F	620 (400 - 830)
3–5	2	522	29.50	14 (12 - 17)	<LOD	13 (9.3 - 16)	30 (22 - 39)	190 (140 - 250)
6–11	2	513	34.11	8.7 (6.3 - 12)	<LOD	4.9^{E} (<LOD - 7.3)	27^{E} (7.8 - 46)	270^{E} (79 - 470)
12–19	2	508	19.09	14 (10 - 20)	<LOD	9.4^{E} (5.1 - 14)	F	500^{E} (290 - 710)
20–39	2	351	19.37	17^{E} (11 - 28)	<LOD	12^{E} (7.6 - 16)	F	680^{E} (290 - 1100)
40–59	2	357	29.13	17^{E} (11 - 28)	<LOD	10^{E} (3.3 - 17)	F	830^{E} (450 - 1200)
60–79	2	289	41.87	—	<LOD	7.2 (<LOD - 9.4)	F	600^{E} (290 - 910)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 11.3.4

Triclosan (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1270	26.85	15 (10 - 21)	<LOD	8.8 (5.7 - 12)	F	700^{E} (360 - 1000)
Males, 6–11	2	261	34.48	8.8^{E} (5.5 - 14)	<LOD	4.2^{E} (<LOD - 6.7)	F	F
Males, 12–19	2	253	18.18	14^{E} (8.9 - 22)	<LOD	8.7^{E} (3.6 - 13)	F	450^{E} (<LOD - 690)
Males, 20–39	2	164	18.29	F	<LOD	F	F	x
Males, 40–59	2	193	25.91	18^{E} (10 - 33)	<LOD	F	F	x
Males, 60–79	2	141	36.88	12^{E} (7.4 - 19)	<LOD	F	F	x
Females, Total 3–79	2	1270	29.76	15 (11 - 19)	<LOD	10 (8.0 - 13)	F	570^{E} (340 - 800)
Females, 6–11	2	252	33.73	8.5^{E} (5.6 - 13)	<LOD	6.2^{E} (<LOD - 9.5)	22^{E} (6.3 - 38)	F
Females, 12–19	2	255	20.00	15^{E} (10 - 22)	<LOD	9.7^{E} (4.3 - 15)	F	610^{E} (280 - 950)
Females, 20–39	2	187	20.32	19^{E} (10 - 34)	<LOD	12^{E} (3.5 - 21)	F	x
Females, 40–59	2	164	32.93	17^{E} (9.6 - 30)	<LOD	F	F	x
Females, 60–79	2	148	46.62	—	<LOD	7.9 (<LOD - 11)	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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NICOTINE METABOLITE SUMMARY AND RESULTS

12

12.1 COTININE

Cotinine (CASRN 486-56-6) is the primary metabolite of nicotine, a chemical found naturally in the tobacco plant and present in tobacco products such as cigarettes, cigars, and smokeless tobacco products (e.g.chewing tobacco and snuff). Nicotine is also incorporated into nicotine replacement therapies such as the nicotine gum, patch, lozenge, inhaler, and buccal spray.

Human exposure to nicotine occurs primarily through the use of tobacco products, exposure to environmental tobacco smoke, and the use of nicotine replacement therapies (HSDB, 2009). In addition, infants breast fed by women who smoke may be exposed to nicotine in breast milk (HSDB, 2009).

Inhalation is the most effective intake route with on average 60% to 80% of nicotine absorbed through the lungs (Iwase et al., 1991). Nicotine can also be absorbed through the skin and gastrointestinal tract, but at a much lower efficiency (Karaconji, 2005). Once inside the body, approximately 70% to 80% of nicotine is metabolized into cotinine. It has a half-life of 10 to 20 hours and can remain in the body at detectable levels for up to 4 days (Benowitz & Jacob, 1994; Curvall et al., 1990). Cotinine is considered to be the best biomarker for exposure to tobacco products and tobacco smoke (Brown et al., 2005; CDC, 2009).

Tobacco smoke is a combination of gases, liquids, and breathable particles, some of which are harmful to human health. It contains over 4,000 chemicals, including at least 70 that cause, initiate, or promote cancer, and has been classified by the International Agency for Research on Cancer (IARC) as Group 1, carcinogenic to humans (Health Canada, 2011; IARC, 2004). Exposure to these chemicals also contributes directly to other diseases, such emphysema and heart disease, and an increased risk of asthma (CDC, 2004). Most of these chemicals are formed during the combustion of tobacco; others are found naturally in tobacco and are released as the tobacco burns (CDC, 2004). Smokeless tobaccos, including chewing tobacco and snuff, contain 28 known cancer-causing chemicals and, similar to the tobaccos used in cigarettes, pipes, and cigars, can lead to nicotine dependence and addiction (Health Canada, 2010; IARC, 2007). Smokeless tobacco use causes oral and pancreatic cancer and has been classified by IARC as Group 1, carcinogenic to humans (IARC, 2007). It can also cause serious dental health problems including recession of the gums, tooth loss, and discolouration of the teeth and gums (Walsh & Epstein, 2000). Levels of cotinine in the blood and urine of non-smokers have been correlated with some adverse health effects related to tobacco smoke exposure, and cotinine itself may contribute to the neuropharmacological effects of tobacco smoking (Benowitz, 1996; Crooks & Dwoskin, 1997).

As a result of the adverse health effects associated with tobacco use, the Government of Canada, along with provincial and territorial governments and various municipalities, has taken several steps to reduce the prevalence of tobacco use as well as exposure to tobacco smoke. These steps include prohibitions on the sale of tobacco to youth, requirements to apply health warnings on tobacco packaging, and restrictions on the promotion of tobacco products including the display of tobacco products at retail outlets (Health Canada, 2006). Additional steps include the offer of cessation help along with initiatives to eliminate smoking in workplaces and enclosed public locations (Health Canada, 2006).

In 1992, a biomonitoring study of 232 anglers in two regions of the Great Lakes area of Ontario showed non-smokers to have a median urinary cotinine level of 12.4 µg/g creatinine, whereas smokers had a median urinary cotinine level of 2,583.7 µg/g creatinine (Kearney et al., 1995). A concentration of 50 µg/L urine for cotinine is recommended for determining smoking status; levels greater than this concentration are attributed to smokers (SRNT Subcommittee on Biochemical Verification, 2002).

Cotinine was measured in the urine of all CHMS participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented as both µg/L and µg/g creatinine for non-smokers (Tables 12.1.1 to 12.1.6) and smokers (Tables 12.1.7 to 12.1.10). Survey participants aged 3 to 11 years were assumed to be non-smokers. In this survey, a smoker is defined as someone who is a current daily or occasional smoker and a non-smoker is defined as someone who does not currently smoke and has either never smoked or who was previously a daily or occasional smoker. Finding a measurable amount of cotinine in urine is an indicator of exposure to nicotine and does not necessarily mean that an adverse health effect will occur.

Table 12.1.1

Cotinine (non-smokers) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	4711	85.82	—	<LOD	<LOD	<LOD	F
Total, 6–79	2	4907	86.90	—	<LOD	<LOD	<LOD	F
Males, Total 6–79	1	2258	82.91	—	<LOD	<LOD	<LOD	F
Males, Total 6–79	2	2312	84.56	—	<LOD	<LOD	<LOD	F
Females, Total 6–79	1	2453	88.50	—	<LOD	<LOD	<LOD	9.9^{E} (3.4 - 16)
Females, Total 6–79	2	2595	88.98	—	<LOD	<LOD	<LOD	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 12.1.2

Cotinine (non-smokers) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	5480	86.86	—	<LOD	<LOD	<LOD	F
3–5[b]	1							
3–5	2	573	86.56	—	<LOD	<LOD	<LOD	F
6–11	1	1045	83.83	—	<LOD	<LOD	<LOD	10[E] (5.7 - 14)
6–11	2	1061	83.79	—	<LOD	<LOD	<LOD	12[E] (6.3 - 18)
12–19	1	889	80.20	—	<LOD	<LOD	<LOD	19[E] (8.2 - 30)
12–19	2	940	80.21	—	<LOD	<LOD	<LOD	F
20–39	1	874	85.35	—	<LOD	<LOD	<LOD	F
20–39	2	1009	86.22	—	<LOD	<LOD	<LOD	F
40–59	1	947	88.81	—	<LOD	<LOD	<LOD	F
40–59	2	972	91.56	—	<LOD	<LOD	<LOD	F
60–79	1	956	90.69	—	<LOD	<LOD	<LOD	F
60–79	2	925	93.08	—	<LOD	<LOD	<LOD	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 12.1.3

Cotinine (non-smokers) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2602	84.93	—	<LOD	<LOD	<LOD	F
Males, 6–11	1	528	82.39	—	<LOD	<LOD	<LOD	9.9[E] (5.6 - 14)
Males, 6–11	2	532	84.77	—	<LOD	<LOD	<LOD	15[E] (6.5 - 24)
Males, 12–19	1	458	77.51	—	<LOD	<LOD	F	F
Males, 12–19	2	489	77.10	—	<LOD	<LOD	F	F
Males, 20–39	1	367	82.83	—	<LOD	<LOD	<LOD	F
Males, 20–39	2	404	80.45	—	<LOD	<LOD	F	F
Males, 40–59	1	436	83.94	—	<LOD	<LOD	<LOD	F
Males, 40–59	2	466	89.91	—	<LOD	<LOD	<LOD	F
Males, 60–79	1	469	87.85	—	<LOD	<LOD	<LOD	F
Males, 60–79	2	421	90.97	—	<LOD	<LOD	<LOD	F
Females, Total 3–79[c]	1							
Females, Total 3–79	2	2878	88.60	—	<LOD	<LOD	<LOD	F
Females, 6–11	1	517	85.30	—	<LOD	<LOD	<LOD	F
Females, 6–11	2	529	82.80	—	<LOD	<LOD	<LOD	F
Females, 12–19	1	431	83.06	—	<LOD	<LOD	<LOD	14[E] (5.3 - 23)
Females, 12–19	2	451	83.59	—	<LOD	<LOD	<LOD	F
Females, 20–39	1	507	87.18	—	<LOD	<LOD	<LOD	F
Females, 20–39	2	605	90.08	—	<LOD	<LOD	<LOD	F
Females, 40–59	1	511	92.95	—	<LOD	<LOD	<LOD	F
Females, 40–59	2	506	93.08	—	<LOD	<LOD	<LOD	F
Females, 60–79	1	487	93.43	—	<LOD	<LOD	<LOD	F
Females, 60–79	2	504	94.84	—	<LOD	<LOD	<LOD	F

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 12.1.4

Cotinine (non-smokers) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	4701	86.00	—	<LOD	<LOD	<LOD	F
Total, 6–79	2	4895	87.11	—	<LOD	<LOD	<LOD	F
Males, Total 6–79	1	2252	83.13	—	<LOD	<LOD	<LOD	F
Males, Total 6–79	2	2307	84.74	—	<LOD	<LOD	<LOD	F
Females, Total 6–79	1	2449	88.65	—	<LOD	<LOD	<LOD	F
Females, Total 6–79	2	2588	89.22	—	<LOD	<LOD	<LOD	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

F Data is too unreliable to be published.

Table 12.1.5

Cotinine (non-smokers) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	5467	87.07	—	<LOD	<LOD	<LOD	F
3–5[b]	1							
3–5	2	572	86.71	—	<LOD	<LOD	<LOD	F
6–11	1	1042	84.07	—	<LOD	<LOD	<LOD	F
6–11	2	1059	83.95	—	<LOD	<LOD	<LOD	12[E] (5.5 - 19)
12–19	1	888	80.29	—	<LOD	<LOD	<LOD	F
12–19	2	938	80.38	—	<LOD	<LOD	<LOD	F
20–39	1	871	85.65	—	<LOD	<LOD	<LOD	F
20–39	2	1007	86.40	—	<LOD	<LOD	<LOD	F
40–59	1	944	89.09	—	<LOD	<LOD	<LOD	F
40–59	2	970	91.75	—	<LOD	<LOD	<LOD	F
60–79	1	956	90.69	—	<LOD	<LOD	<LOD	F
60–79	2	921	93.49	—	<LOD	<LOD	<LOD	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 12.1.6

Cotinine (non-smokers) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	2596	85.13	—	<LOD	<LOD	<LOD	F
Males, 6–11	1	526	82.70	—	<LOD	<LOD	<LOD	F
Males, 6–11	2	530	85.09	—	<LOD	<LOD	<LOD	12[E] (3.4 - 20)
Males, 12–19	1	457	77.68	—	<LOD	<LOD	<LOD (<LOD - 2.5)	F
Males, 12–19	2	488	77.25	—	<LOD	<LOD	F	F
Males, 20–39	1	366	83.06	—	<LOD	<LOD	<LOD	F
Males, 20–39	2	403	80.65	—	<LOD	<LOD	1.0[E] (<LOD - 1.6)	F
Males, 40–59	1	434	84.33	—	<LOD	<LOD	<LOD	F
Males, 40–59	2	466	89.91	—	<LOD	<LOD	<LOD	F
Males, 60–79	1	469	87.85	—	<LOD	<LOD	<LOD	F
Males, 60–79	2	420	91.19	—	<LOD	<LOD	<LOD	F
Females, Total 3–79[c]	1							
Females, Total 3–79	2	2871	88.82	—	<LOD	<LOD	<LOD	F
Females, 6–11	1	516	85.47	—	<LOD	<LOD	<LOD	F
Females, 6–11	2	529	82.80	—	<LOD	<LOD	<LOD	14[E] (5.5 - 22)
Females, 12–19	1	431	83.06	—	<LOD	<LOD	<LOD	9.5[E] (4.1 - 15)
Females, 12–19	2	450	83.78	—	<LOD	<LOD	<LOD	F
Females, 20–39	1	505	87.52	—	<LOD	<LOD	<LOD	F
Females, 20–39	2	604	90.23	—	<LOD	<LOD	<LOD	F
Females, 40–59	1	510	93.14	—	<LOD	<LOD	<LOD	F
Females, 40–59	2	504	93.45	—	<LOD	<LOD	<LOD	5.1 (<LOD - 6.9)
Females, 60–79	1	487	93.43	—	<LOD	<LOD	<LOD	F
Females, 60–79	2	501	95.41	—	<LOD	<LOD	<LOD	F

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 12.1.7

Cotinine (smokers) — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79	1	805	4.22	590 (420 - 820)	F	1000 (810 - 1200)	1600 (1500 - 1800)	2600 (2300 - 2900)
Total, 12–79	2	819	5.74	490 (340 - 700)	F	1000 (810 - 1200)	1700 (1400 - 1900)	2600 (2100 - 3100)
12–19	1	102	10.78	160^{E} (80 - 330)	F	F	1200 (930 - 1500)	x
12–19	2	102	11.76	F	<LOD	F	F	x
20–39	1	300	3.00	500^{E} (300 - 850)	F	930 (620 - 1200)	1500 (1400 - 1700)	2500 (2100 - 2900)
20–39	2	311	9.00	400^{E} (260 - 630)	F	850 (570 - 1100)	1400 (1100 - 1700)	2900 (2200 - 3600)
40–59	1	275	3.27	830 (610 - 1100)	F	1200 (910 - 1500)	1900 (1500 - 2200)	2800 (2400 - 3100)
40–59	2	253	1.58	800^{E} (470 - 1300)	F	1400 (1000 - 1700)	1900 (1700 - 2100)	2600 (2000 - 3300)
60–79	1	128	3.91	660^{E} (440 - 980)	F	860 (600 - 1100)	1600 (1400 - 1800)	x
60–79	2	153	1.96	F	F	980 (720 - 1200)	1300 (1100 - 1500)	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 12.1.8

Cotinine (smokers) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 12–79 years by sex and age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79	1	406	4.43	660[E] (400 - 1100)	F	1200 (920 - 1500)	1800 (1600 - 2100)	2800 (2400 - 3300)
Males, Total 12–79	2	425	4.47	470[E] (280 - 780)	F	1000 (780 - 1200)	1600 (1300 - 2000)	2900 (2300 - 3500)
Males, 12–19	1	48	12.50	F	x	F	1300[E] (800 - 1800)	x
Males, 12–19	2	54	5.56	F	x	F	1300[E] (420 - 2100)	x
Males, 20–39	1	149	2.68	F	F	880[E] (440 - 1300)	1600 (1300 - 1900)	x
Males, 20–39	2	146	7.53	530[E] (330 - 850)	F	1000[E] (650 - 1400)	1700 (1100 - 2300)	x
Males, 40–59	1	140	3.57	980[E] (620 - 1500)	F	1600 (1200 - 2000)	2100 (1900 - 2300)	x
Males, 40–59	2	147	2.04	F	F	1000[E] (610 - 1400)	1700 (1300 - 2100)	x
Males, 60–79	1	69	4.35	910 (650 - 1300)	x	1300[E] (770 - 1900)	1700 (1300 - 2200)	x
Males, 60–79	2	78	2.56	F	x	990[E] (540 - 1400)	1400 (1100 - 1600)	x
Females, Total 12–79	1	399	4.01	520 (390 - 700)	F	860 (640 - 1100)	1300 (1100 - 1500)	2500 (2300 - 2700)
Females, Total 12–79	2	394	7.11	510[E] (320 - 820)	F	1000 (720 - 1300)	1700 (1500 - 2000)	2400 (1900 - 2900)
Females, 12–19	1	54	9.26	F	x	F	F	x
Females, 12–19	2	48	18.75	F	x	F	570[E] (270 - 860)	x
Females, 20–39	1	151	3.31	490[E] (330 - 710)	F	940[E] (580 - 1300)	1400 (1100 - 1700)	x
Females, 20–39	2	165	10.30	F	<LOD	690[E] (430 - 950)	1300 (1100 - 1500)	x
Females, 40–59	1	135	2.96	710 (520 - 960)	F	920 (680 - 1200)	1300 (940 - 1700)	x
Females, 40–59	2	106	0.94	1200[E] (850 - 1800)	F	1700 (1400 - 2000)	1900 (1600 - 2200)	x
Females, 60–79	1	59	3.39	480[E] (280 - 850)	x	660 (430 - 890)	1100[E] (520 - 1800)	x
Females, 60–79	2	75	1.33	800 (650 - 970)	x	870 (600 - 1100)	1300 (1000 - 1500)	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 12.1.9

Cotinine (smokers) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79	1	803	4.23	660 (480 - 890)	F	1000 (830 - 1200)	1800 (1500 - 2100)	4400 (3500 - 5300)
Total, 12–79	2	816	5.76	430^{E} (290 - 630)	F	840 (590 - 1100)	1600 (1300 - 2000)	3800^{E} (2300 - 5200)
12–19	1	102	10.78	120^{E} (59 - 250)	F	290^{E} (<LOD - 470)	670^{E} (340 - 990)	x
12–19	2	102	11.76	F	<LOD	F	800^{E} (260 - 1300)	x
20–39	1	299	3.01	510^{E} (310 - 840)	F	850 (560 - 1100)	1400 (1100 - 1700)	2500 (1900 - 3000)
20–39	2	311	9.00	330^{E} (200 - 530)	F	700 (460 - 950)	1400 (910 - 1900)	3200^{E} (1700 - 4700)
40–59	1	275	3.27	1000 (810 - 1300)	F	1300 (920 - 1600)	2500 (1800 - 3200)	5500 (4400 - 6600)
40–59	2	251	1.59	710^{E} (400 - 1300)	F	1000^{E} (560 - 1500)	1900 (1300 - 2600)	4900^{E} (2800 - 6900)
60–79	1	127	3.94	840^{E} (530 - 1300)	F	1300 (1000 - 1500)	1800 (1400 - 2200)	x
60–79	2	152	1.97	F	F	1100 (720 - 1400)	1900^{E} (1100 - 2700)	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 12.1.10

Cotinine (smokers) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 12–79 years by sex and age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79	1	405	4.44	560[E] (360 - 880)	F	930 (680 - 1200)	1500 (1200 - 1700)	3200 (2300 - 4200)
Males, Total 12–79	2	425	4.47	370[E] (210 - 630)	F	730 (470 - 990)	1400 (1000 - 1700)	3700[E] (2400 - 5100)
Males, 12–19	1	48	12.50	F	x	F	F	x
Males, 12–19	2	54	5.56	F	x	F	F	x
Males, 20–39	1	148	2.70	420[E] (220 - 790)	F	630[E] (360 - 900)	1200 (970 - 1400)	x
Males, 20–39	2	146	7.53	390[E] (220 - 680)	F	740[E] (450 - 1000)	1300 (900 - 1800)	x
Males, 40–59	1	140	3.57	850[E] (530 - 1400)	F	1200 (870 - 1500)	1800 (1400 - 2200)	x
Males, 40–59	2	147	2.04	F	F	F	1400[E] (540 - 2200)	x
Males, 60–79	1	69	4.35	980 (720 - 1300)	x	1300 (970 - 1700)	1800 (1300 - 2300)	x
Males, 60–79	2	78	2.56	F	x	880[E] (440 - 1300)	1800[E] (820 - 2800)	x
Females, Total 12–79	1	398	4.02	780 (590 - 1000)	F	1100 (900 - 1400)	2200 (1700 - 2800)	5500 (4300 - 6600)
Females, Total 12–79	2	391	7.16	520[E] (300 - 900)	F	1000 (670 - 1400)	1900 (1300 - 2400)	4800[E] (2300 - 7300)
Females, 12–19	1	54	9.26	99[E] (51 - 190)	x	F	F	x
Females, 12–19	2	48	18.75	F	x	F	F	x
Females, 20–39	1	151	3.31	680[E] (450 - 1000)	F	1100 (760 - 1400)	1900 (1400 - 2400)	x
Females, 20–39	2	165	10.30	F	<LOD	700[E] (310 - 1100)	1400[E] (580 - 2200)	x
Females, 40–59	1	135	2.96	1300 (950 - 1700)	310[E] (<LOD - 480)	1600[E] (800 - 2500)	3200 (2400 - 3900)	x
Females, 40–59	2	104	0.96	1300[E] (860 - 1900)	F	1500 (1100 - 2000)	F	x
Females, 60–79	1	58	3.45	730[E] (370 - 1400)	x	1200 (840 - 1500)	1800[E] (1100 - 2500)	x
Females, 60–79	2	74	1.35	1100 (800 - 1600)	x	1500[E] (820 - 2100)	2200[E] (1300 - 3000)	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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PERFLUOROALKYL SUBSTANCES SUMMARY AND RESULTS

13

Perfluoroalkyl substances (PFASs) are members of a structurally related class of persistent organic compounds. This class is characterized by the presence of a perfluoroalkyl chain that is typically four to 14 carbons in length and in which all hydrogen atoms are replaced by fluorine atoms. In cycle 2 of the Canadian Health Measures Survey (CHMS), nine PFASs were measured (Table 13.1).

Table 13.1

Perfluoroalkyl substances measured in the Canadian Health Measures Survey cycle 2 (2009–2011).

Perfluoroalkyl substance	CASRN
Perfluorobutanoic acid (PFBA)	375-22-4
Perfluorohexanoic acid (PFHxA)	307-24-4
Perfluorooctanoic acid (PFOA)	335-67-1
Perfluorononanoic acid (PFNA)	375-95-1
Perfluorodecanoic acid (PFDA)	335-76-2
Perfluoroundecanoic acid (PFUnDA)	2058-94-8
Perfluorobutane sulfonate (PFBS)	45187-15-3
Perfluorohexane sulfonate (PFHxS)	108427-53-8
Perfluorooctane sulfonate (PFOS)	45298-90-6

The PFASs most extensively studied and measured in humans are PFOS and PFOA (Dallaire et al., 2009; Hölzer et al., 2008; Kato et al., 2011). PFHxS is another perfluorinated compound that has been measured in humans, but it has not been examined as extensively as PFOS and PFOA. Other PFASs, such as PFBA, PFHxA, PFNA, PFDA, PFUnDA, and PFBS, are measured less frequently in the human population.

PFASs are synthetic chemicals with high chemical and thermal stability and are able to repel both water and oils (Kissa, 2001). These characteristics make them ideal for use in a number of industrial and commercial applications (Kissa, 2001). PFASs are used as stain-repellent, water-repellent, and oil-repellent fabric protectors, in water-repellent and oil-repellent paper coatings, wiper blades, bike-chain lubricant, wire and cable insulation, pharmaceutical packaging, and food packaging (Kissa, 2001). They are also used in engine-oil additives, nail polish, hair curling and straightening products, metal plating and cleaning, fire retardant foams, inks, varnishes, polyurethane production, and vinyl polymerization (Kissa, 2001). Fluoropolymers manufactured using salts of PFASs are used in many industrial and consumer products including surface coatings on textiles and carpets, in personal-care products, and in non-stick coatings on cookware (Indian and Northern Affairs Canada, 2009; Kissa, 2001; Prevedouros et al., 2005).

Worldwide use of PFOS and PFOS-related products has decreased significantly since 2002 when the world's largest producer at the time completed its voluntary phase-out of production (3M, 2012). PFHxS, a known by-product in the production of PFOS, was also phased out as a result. In 2008, replacements for PFOA were introduced, resulting in the subsequent phase-out of PFOA use in the production of fluoropolymers (3M, 2012). Potential replacements for PFOS-based substances include new PFBS-based compounds that are rapidly eliminated from the body with a relatively low bioaccumulation potential and toxicity (Chang et al., 2008; Newsted et al., 2008).

PFASs do not occur naturally in the environment. Entry into the environment occurs through releases during manufacturing and transport, use of consumer products, and the disposal and breakdown of larger PFASs. As a result, PFASs have been detected in a wide array of environmental media (Houde et al., 2006).

Exposure to the general public is widespread through food, drinking water, consumer products, dust, soil, and air (Fromme et al., 2009; Fromme et al., 2007; Hölzer et al., 2008; Kubwabo et al., 2005). PFASs have been analyzed as part of Health Canada's ongoing Total Diet Study surveys; levels in foods that are commercially sold in Canada are low and within a similar range as have been reported in other countries (Health Canada, 2009; Tittlemier et al., 2007; Tittlemier et al., 2006). The contribution of individual pathways and sources of exposure appear to depend on age, dose, and substance. Generally, ingestion of food, drinking water, and house dust are expected to be the main routes of exposure for adults in the general population whereas oral hand-to-mouth contact with consumer products, such as carpets, clothing, and upholstery, is a significant contributor for infants, toddlers, and children (Trudel et al., 2008).

Longer chain PFASs are well absorbed in the body, poorly excreted, and are not extensively metabolized (Harada et al., 2005; Indian and Northern Affairs Canada, 2009; Johnson et al., 1984). Average half-lives of PFOS, PFOA, and PFHxS in humans range from 3 to 9 years (Olsen et al., 2007). However, shorter chain PFASs are eliminated much more quickly; for example, the elimination half-life for PFBA is 72 to 81 hours (ATSDR, 2009). In humans, PFOS and PFOA are found in serum, plasma, kidneys, and the liver (Butenhoff et al., 2006; Fromme et al., 2009; Kärrman et al., 2010). PFASs have also been measured in breast milk and umbilical cord blood (Kärrman et al., 2010; Monroy et al., 2008). PFASs have a strong affinity for the protein fraction in blood and do not typically accumulate in lipids (Kärrman et al., 2010; Martin et al., 2004). Absorbed PFOA and PFOS are ultimately excreted in urine (ATSDR, 2009). Serum levels of PFASs, in particular PFOA and PFOS, can be reflective of cumulative exposure over several years (CDC, 2009). Although both PFOA and PFOS are biomarkers of exposures to themselves, animal studies have indicated that their presence in serum may also result from exposure to and subsequent metabolism of other PFASs (ATSDR, 2009).

The primary concern with PFASs is their persistence in both the environment and the human body (Olsen et al., 2007). Possible linkages between exposure to PFASs and adverse human health effects have been examined in occupational studies and studies of populations exposed to contaminated drinking water (ATSDR, 2009). Although no definitive links have been established, a recent large-scale report in children suggests associations between serum PFASs and thyroid effects (Lopez-Espinosa et al., 2012). In several animal species, the liver has been identified as the primary target organ of toxicity for PFASs regardless of the route of exposure (EPA, 2002; Health Canada, 2006). PFOA has been associated with increased incidence of tumours in rodent bioassays, and PFOA and other PFASs were identified in 2008 as priority agents for future International Agency for Research on Cancer monographs (IARC, 2008).

In 2006, Environment Canada and Health Canada concluded that PFOS was not a concern for human health at current levels of exposure (Health Canada, 2006). However, PFOS and its salts were declared toxic to the environment and its biological diversity, and PFOS was added to Schedule 1 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; Environment Canada, 2006a). In 2009, PFOS and its salts were added to the Virtual Elimination List under CEPA 1999 (Canada, 2009). Canada is also working through the Convention on Long-Range Transboundary Air Pollution and the Stockholm Convention on Persistent Organic Pollutants under the United Nations to reduce the global production of PFOS (Canada, 2010a).

In 2012, Environment Canada and Health Canada published screening assessments of PFOA and long-chain (C9-C20) perfluorocarboxylic acids (including PFNA, PFDA, and PFUnDA), along with their salts and their precursors (Environment Canada, 2012; Environment Canada & Health Canada, 2012a). The assessments concluded that the substances are an ecological concern, but PFOA and its salts and precursors are not a concern for human life or health (Environment Canada, 2012; Environment Canada & Health Canada, 2012a). Long-chain perfluorocarboxylic acids and their salts and precursors were not considered to be a high priority for assessment of potential risks to human health; as such, no human health assessment was conducted. Based on the assessments, both PFOA and long-chain perfluorocarboxylic acids and their salts and precursors have been added to the List of Toxic Substances in Schedule 1 of CEPA 1999 (Canada, 2012).

A number of risk management actions have been taken in Canada following the Government of Canada's publication of *Perfluorinated Carboxylic Acids (PFCAs) and Precursors: An Action Plan for Assessment and Management* in 2006 (Environment Canada, 2006b). These actions include regulations prohibiting the manufacture, use, sale, offer for sale, and import of four fluorotelomer-based substances found to be precursors to long-chain perfluorinated carboxylic acids, unless present in certain manufactured items (Canada, 2010b). Additionally in 2010, the voluntary *Environmental Performance Agreement Respecting Perfluorinated Carboxylic Acids (PFCAs) and Their Precursors in Perfluorochemical Products Sold in Canada* was signed by four companies with the aim of addressing confirmed sources of PFCAs from substances already in Canadian commerce (Environment Canada, 2010).

Globally, there is an initiative to reduce PFOA emissions and product content. In 2006, the United States Environmental Protection Agency and eight major companies in the industry launched the 2010/15 PFOA Stewardship Program. Under this voluntary effort, companies were committed to reduce global facility emissions and product content of PFOA and related chemicals by 95% by 2010, and to work toward eliminating emissions and product content by 2015 (EPA, 2012a). As of 2012, more than 150 replacement chemicals have been developed, and the companies are on track to phase out PFOA and related chemicals by the end of 2015 (EPA, 2012b). Canada's 2010 Environmental Performance Agreement is consistent with the targets and commitments by industry in the United States (Environment Canada, 2010). The European Union and the Australian government have initiated similar policies where PFASs are either prohibited or subject to further toxicity testing for evaluation.

Several human biomonitoring studies in Canada have measured PFASs in serum and plasma (Alberta Health and Wellness, 2008; Hamm et al., 2010; Kubwabo et al., 2004; Monroy et al., 2008; Tittlemier et al., 2004; Turgeon O'Brien et al., 2012). Serum concentrations of some PFASs in children appear to be higher than in adults and may be related to differences in sources and routes of exposure between these two age groups (Calafat et al., 2007a; Calafat et al., 2007b; Kato et al., 2009). In 2002, serum samples from 56 individuals in Ottawa, Ontario, and Gatineau, Quebec, were analyzed for PFOS and PFOA. PFOS was detected in all samples with a mean concentration of 28.8 µg/L and a range of 3.7 to 65.1 µg/L (Kubwabo et al., 2004). The concentration of PFOA was considerably lower, with a mean of 3.4 µg/L and a range from <1.2 to 7.2 µg/L (Kubwabo et al., 2004). In 2004, PFOS was measured in the plasma samples from 883 Nunavik Inuit living in the Canadian Arctic (Dallaire et al., 2009). PFOS was detected in all tested samples, with a geometric mean concentration of 18.68 µg/L (Dallaire et al., 2009). The concentrations of PFASs were measured in 155 Inuit infants attending childcare centres in Nunavik (Turgeon O'Brien et al., 2012). Both PFOS and PFOA were detected in all plasma samples with geometric means of 3.36 µg/L and 1.61 µg/L, respectively.

PFOS, PFOA, and PFHxS were measured in the plasma of all CHMS participants aged 20 to 79 years in cycle 1 (2007–2009) and 12 to 79 years in cycle 2 (2009–2011). PFBA, PFHxA, PFBS, PFNA, PFDA, and PFUnDA were measured in the plasma of all CHMS participants aged 12 to 79 years in cycle 2 (2009–2011). Data for the PFASs are presented as µg/L in plasma (Tables 13.1.1 to 13.9.3). Finding a measurable amount of PFASs in plasma is an indicator of exposure to PFASs and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for plasma levels of PFBA, PFHxA, PFBS, PFNA, PFDA, and PFUnDA in the Canadian population.

13.1 PERFLUOROBUTANOIC ACID (PFBA)

Table 13.1.1

Perfluorobutanoic acid (PFBA) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79	2	1524	99.67	—	<LOD	<LOD	<LOD	<LOD
12–19	2	507	99.41	—	<LOD	<LOD	<LOD	<LOD
20–39	2	362	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	334	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	321	99.38	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 13.1.1

Perfluorobutanoic acid (PFBA) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79	2	765	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	170	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	176	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	165	100	—	<LOD	<LOD	<LOD	x
Females, Total 12–79	2	759	99.34	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	253	98.81	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	192	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	158	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	156	98.72	—	<LOD	<LOD	<LOD	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

13.2 PERFLUOROHEXANOIC ACID (PFHxA)

Table 13.2.1

Perfluorohexanoic acid (PFHxA) — Geometric means and selected percentiles of plasma concentrations (μg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79	2	1524	98.10	—	<LOD	<LOD	<LOD	<LOD
12–19	2	507	98.22	—	<LOD	<LOD	<LOD	<LOD
20–39	2	362	98.07	—	<LOD	<LOD	<LOD	<LOD
40–59	2	334	98.20	—	<LOD	<LOD	<LOD	<LOD
60–79	2	321	97.82	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 13.2.2

Perfluorohexanoic acid (PFHxA) — Geometric means and selected percentiles of plasma concentrations (μg/L) for the Canadian population aged 12–79 years by sex and age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79	2	765	98.30	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	99.21	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	170	98.24	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	176	97.16	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	165	98.18	—	<LOD	<LOD	<LOD	x
Females, Total 12–79	2	759	97.89	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	253	97.23	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	192	97.92	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	158	99.37	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	156	97.44	—	<LOD	<LOD	<LOD	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

13.3 PERFLUOROOCTANOIC ACID (PFOA)

Table 13.3.1

Perfluorooctanoic acid (PFOA) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 20–79	1	2880	1.11	2.5 (2.4 - 2.7)	1.3 (1.1 - 1.4)	2.6 (2.4 - 2.8)	3.6 (3.4 - 3.8)	5.5 (5.1 - 5.8)
Total, 20–79	2	1017	0	2.3 (2.1 - 2.5)	1.1 (0.91 - 1.2)	2.4 (2.1 - 2.6)	3.3 (2.9 - 3.7)	5.3 (3.9 - 6.7)
Males, Total 20–79	1	1376	0.51	2.9 (2.7 - 3.2)	1.6 (1.4 - 1.7)	3.1 (2.8 - 3.3)	4.0 (3.7 - 4.3)	5.9 (5.4 - 6.4)
Males, Total 20–79	2	511	0	2.6 (2.4 - 2.9)	1.3 (0.99 - 1.6)	2.7 (2.5 - 2.9)	3.5 (3.2 - 3.9)	6.0 (4.3 - 7.7)
Females, Total 20–79	1	1504	1.66	2.2 (2.0 - 2.4)	1.0 (0.92 - 1.2)	2.2 (2.1 - 2.4)	3.1 (2.9 - 3.3)	5.0 (4.4 - 5.5)
Females, Total 20–79	2	506	0	2.0 (1.8 - 2.2)	0.92 (0.73 - 1.1)	2.0 (1.7 - 2.3)	2.9 (2.2 - 3.5)	4.4 (3.8 - 5.1)

a For the purpose of total population comparisons, only values from participants aged 20–79 years were included as participants under the age of 20 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 13.3.2

Perfluorooctanoic acid (PFOA) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and Cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79[b]	1							
Total, 12–79	2	1524	0	2.3 (2.1 - 2.5)	1.1 (0.93 - 1.2)	2.3 (2.1 - 2.5)	3.2 (2.8 - 3.6)	5.0 (3.6 - 6.4)
12–19[b]	1							
12–19	2	507	0	2.1 (1.9 - 2.3)	1.2 (1.0 - 1.4)	2.1 (1.9 - 2.3)	2.6 (2.4 - 2.8)	4.1 (3.6 - 4.5)
20–39	1	979	1.12	2.4 (2.2 - 2.7)	1.1 (0.95 - 1.3)	2.5 (2.3 - 2.8)	3.6 (3.3 - 3.8)	5.4 (4.8 - 5.9)
20–39	2	362	0	2.2 (1.9 - 2.5)	0.88 (0.64 - 1.1)	2.3 (1.9 - 2.8)	3.2 (2.8 - 3.7)	5.8 (3.9 - 7.6)
40–59	1	983	1.02	2.5 (2.3 - 2.7)	1.3 (1.2 - 1.4)	2.5 (2.3 - 2.8)	3.5 (3.2 - 3.7)	5.4 (4.6 - 6.1)
40–59	2	334	0	2.2 (2.0 - 2.4)	1.1 (0.87 - 1.3)	2.1 (1.7 - 2.5)	3.1 (2.7 - 3.6)	4.4 (3.9 - 5.0)
60–79	1	918	1.20	2.8 (2.5 - 3.0)	1.5 (1.3 - 1.7)	2.8 (2.6 - 3.0)	3.9 (3.5 - 4.4)	6.3 (5.4 - 7.1)
60–79	2	321	0	2.8 (2.4 - 3.2)	1.5 (1.0 - 2.0)	2.7 (2.1 - 3.2)	3.7 (3.1 - 4.3)	6.4 (4.6 - 8.1)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 20 years were not included in cycle 1 (2007–2009).

Table 13.3.3

Perfluorooctanoic acid (PFOA) — Geometric means and selected percentiles of plasma concentrations (μg/L) for the Canadian population aged 12–79 years by sex and age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79[b]	1							
Males, Total 12–79	2	765	0	2.6 (2.4 - 2.8)	1.3 (1.0 - 1.6)	2.7 (2.5 - 2.9)	3.4 (3.1 - 3.7)	5.9 (4.3 - 7.6)
Males, 12–19[b]	1							
Males, 12–19	2	254	0	2.2 (2.1 - 2.3)	1.5 (1.3 - 1.6)	2.2 (2.0 - 2.3)	2.7 (2.5 - 2.9)	4.3 (3.6 - 4.9)
Males, 20–39	1	435	0	3.1 (2.8 - 3.4)	1.7 (1.5 - 1.9)	3.2 (3.0 - 3.5)	4.1 (3.7 - 4.4)	5.8 (5.1 - 6.5)
Males, 20–39	2	170	0	2.9 (2.6 - 3.3)	1.7 (1.1 - 2.3)	2.8 (2.3 - 3.3)	3.9 (3.0 - 4.9)	x
Males, 40–59	1	480	0.42	2.9 (2.6 - 3.1)	1.5 (1.3 - 1.7)	2.9 (2.6 - 3.3)	3.9 (3.5 - 4.3)	5.7 (4.9 - 6.5)
Males, 40–59	2	176	0	2.3 (2.0 - 2.5)	1.0 (0.79 - 1.3)	2.4 (2.0 - 2.8)	3.3 (2.9 - 3.7)	x
Males, 60–79	1	461	1.08	2.8 (2.5 - 3.2)	1.5 (1.2 - 1.8)	2.9 (2.6 - 3.2)	4.1 (3.5 - 4.7)	6.4 (5.3 - 7.6)
Males, 60–79	2	165	0	2.8 (2.5 - 3.1)	1.7 (1.2 - 2.2)	2.9 (2.5 - 3.3)	3.5 (3.1 - 3.9)	x
Females, Total 12–79[b]	1							
Females, Total 12–79	2	759	0	2.0 (1.8 - 2.2)	0.99 (0.81 - 1.2)	2.0 (1.8 - 2.2)	2.8 (2.3 - 3.4)	4.4 (3.9 - 4.9)
Females, 12–19[b]	1							
Females, 12–19	2	253	0	2.0 (1.7 - 2.3)	1.1 (0.91 - 1.2)	2.0 (1.6 - 2.4)	2.5 (2.2 - 2.8)	3.9 (3.5 - 4.4)
Females, 20–39	1	544	2.02	1.9 (1.7 - 2.1)	0.95 (0.75 - 1.1)	2.1 (1.8 - 2.3)	2.8 (2.5 - 3.1)	4.3 (3.7 - 5.0)
Females, 20–39	2	192	0	1.5 (1.3 - 1.8)	0.70 (0.59 - 0.81)	1.5 (1.2 - 1.9)	2.3 (1.9 - 2.6)	x
Females, 40–59	1	503	1.59	2.2 (2.0 - 2.4)	1.1 (0.90 - 1.3)	2.2 (2.0 - 2.4)	3.0 (2.8 - 3.2)	4.9 (4.1 - 5.8)
Females, 40–59	2	158	0	2.1 (1.8 - 2.4)	1.1 (0.86 - 1.3)	2.0 (1.5 - 2.5)	3.0 (2.1 - 3.8)	x
Females, 60–79	1	457	1.31	2.7 (2.4 - 3.0)	1.4 (1.2 - 1.7)	2.7 (2.5 - 2.9)	3.7 (3.3 - 4.1)	5.9 (5.3 - 6.5)
Females, 60–79	2	156	0	2.7 (2.2 - 3.5)	1.4[E] (0.85 - 2.0)	2.5 (1.7 - 3.3)	3.9 (3.1 - 4.8)	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 20 years were not included in cycle 1 (2007–2009).

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

13.4 PERFLUORONONANOIC ACID (PFNA)

Table 13.4.1

Perfluorononanoic acid (PFNA) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79	2	1524	1.05	0.82 (0.75 - 0.91)	0.39 (0.33 - 0.44)	0.80 (0.70 - 0.90)	1.1 (0.96 - 1.2)	1.9^{E} (1.1 - 2.7)
12–19	2	507	1.18	0.71 (0.62 - 0.81)	0.33 (0.27 - 0.38)	0.69 (0.63 - 0.75)	0.94 (0.83 - 1.0)	1.7^{E} (0.47 - 2.9)
20–39	2	362	2.21	0.79 (0.72 - 0.87)	0.38 (0.30 - 0.46)	0.77 (0.62 - 0.92)	1.1 (0.93 - 1.2)	F
40–59	2	334	0.60	0.79 (0.69 - 0.91)	0.41 (0.32 - 0.50)	0.78 (0.65 - 0.91)	1.0 (0.86 - 1.1)	1.7 (1.1 - 2.2)
60–79	2	321	0	1.1 (0.87 - 1.3)	0.45^{E} (0.25 - 0.65)	1.0 (0.86 - 1.1)	1.5 (1.1 - 1.8)	2.7^{E} (1.5 - 3.8)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 13.4.2

Perfluorononanoic acid (PFNA) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by sex and age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79	2	765	0.78	0.84 (0.75 - 0.94)	0.43 (0.37 - 0.48)	0.80 (0.69 - 0.91)	1.1 (0.94 - 1.3)	1.9 (1.5 - 2.2)
Males, 12–19	2	254	0.79	0.74 (0.63 - 0.86)	0.37 (0.29 - 0.44)	0.70 (0.65 - 0.75)	0.93 (0.80 - 1.1)	F
Males, 20–39	2	170	1.76	0.84 (0.71 - 1.0)	0.44^{E} (0.27 - 0.61)	0.84 (0.64 - 1.0)	1.1 (0.93 - 1.3)	x
Males, 40–59	2	176	0.57	0.77 (0.65 - 0.90)	0.40^{E} (0.20 - 0.61)	0.77 (0.65 - 0.89)	0.98 (0.81 - 1.1)	x
Males, 60–79	2	165	0	1.1 (0.90 - 1.2)	0.49^{E} (0.32 - 0.67)	0.99 (0.80 - 1.2)	1.5 (1.1 - 1.9)	x
Females, Total 12–79	2	759	1.32	0.81 (0.73 - 0.90)	0.35 (0.30 - 0.40)	0.79 (0.69 - 0.90)	1.1 (0.94 - 1.2)	2.3^{E} (1.2 - 3.4)
Females, 12–19	2	253	1.58	0.68 (0.57 - 0.80)	0.29 (0.22 - 0.37)	0.65 (0.52 - 0.78)	0.96 (0.76 - 1.2)	1.6 (1.2 - 2.0)
Females, 20–39	2	192	2.60	0.73 (0.64 - 0.83)	0.32 (0.24 - 0.39)	0.67 (0.53 - 0.81)	1.0 (0.88 - 1.2)	x
Females, 40–59	2	158	0.63	0.81 (0.69 - 0.96)	0.41 (0.32 - 0.50)	0.81 (0.62 - 1.0)	1.0 (0.81 - 1.2)	x
Females, 60–79	2	156	0	1.1 (0.81 - 1.4)	0.38^{E} (<LOD - 0.64)	1.0 (0.82 - 1.2)	1.5 (0.98 - 1.9)	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

13.5 PERFLUORODECANOIC ACID (PFDA)

Table 13.5.1

Perfluorodecanoic acid (PFDA) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79	2	1524	21.59	0.20 (0.17 - 0.22)	<LOD	0.17 (0.15 - 0.19)	0.27 (0.23 - 0.30)	0.66 (0.45 - 0.87)
12–19	2	507	26.43	0.15 (0.13 - 0.18)	<LOD	0.14 (0.12 - 0.16)	0.20 (0.16 - 0.23)	0.39[E] (0.22 - 0.55)
20–39	2	362	20.72	0.22 (0.20 - 0.23)	<LOD	0.17 (0.16 - 0.19)	0.27 (0.23 - 0.32)	F
40–59	2	334	21.56	0.17 (0.14 - 0.21)	<LOD	0.16 (0.13 - 0.19)	0.24 (0.20 - 0.28)	0.51 (0.35 - 0.66)
60–79	2	321	14.95	0.25 (0.17 - 0.36)	<LOD	0.23 (0.17 - 0.29)	0.37[E] (0.15 - 0.59)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 13.5.2

Perfluorodecanoic acid (PFDA) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by sex and age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79	2	765	20.39	0.20 (0.18 - 0.23)	<LOD	0.18 (0.15 - 0.20)	0.26 (0.23 - 0.30)	0.55 (0.41 - 0.70)
Males, 12–19	2	254	25.98	0.15 (0.13 - 0.18)	<LOD	0.14 (0.12 - 0.16)	0.20 (0.16 - 0.24)	0.38 (0.25 - 0.50)
Males, 20–39	2	170	19.41	0.21 (0.18 - 0.24)	<LOD	0.18 (0.15 - 0.21)	0.26 (0.21 - 0.31)	x
Males, 40–59	2	176	19.89	0.18 (0.15 - 0.23)	<LOD	0.17 (0.13 - 0.20)	0.25 (0.21 - 0.29)	x
Males, 60–79	2	165	13.33	0.26 (0.19 - 0.34)	<LOD	0.23 (0.18 - 0.29)	0.36[E] (0.14 - 0.59)	x
Females, Total 12–79	2	759	22.79	0.19 (0.16 - 0.23)	<LOD	0.17 (0.14 - 0.19)	0.27 (0.22 - 0.33)	F
Females, 12–19	2	253	26.88	0.15 (0.12 - 0.20)	<LOD	0.14 (0.11 - 0.17)	0.20 (0.15 - 0.25)	0.40[E] (0.20 - 0.60)
Females, 20–39	2	192	21.88	0.22 (0.18 - 0.27)	<LOD	0.17 (0.15 - 0.19)	0.30 (0.21 - 0.40)	x
Females, 40–59	2	158	23.42	0.16 (0.12 - 0.21)	<LOD	0.15 (<LOD - 0.21)	0.24 (0.18 - 0.29)	x
Females, 60–79	2	156	16.67	0.24[E] (0.15 - 0.39)	<LOD	0.23[E] (0.14 - 0.31)	0.37[E] (0.13 - 0.61)	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

13.6 PERFLUOROUNDECANOIC ACID (PFUnDA)

Table 13.6.1

Perfluoroundecanoic acid (PFUnDA) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79	2	1522	39.29	0.12 (0.098 - 0.14)	<LOD	0.095 (<LOD - 0.10)	0.18 (0.14 - 0.22)	0.56^{E} (0.30 - 0.82)
12–19	2	506	58.30	—	<LOD	<LOD	0.098 (<LOD - 0.12)	0.30 (0.21 - 0.38)
20–39	2	362	37.02	0.13 (0.10 - 0.16)	<LOD	0.098 (<LOD - 0.12)	0.20 (0.15 - 0.25)	0.64^{E} (0.22 - 1.1)
40–59	2	334	26.35	0.11 (0.094 - 0.14)	<LOD	0.095 (<LOD - 0.10)	0.16 (0.10 - 0.22)	0.43 (0.28 - 0.58)
60–79	2	320	25.31	0.14^{E} (<LOD - 0.23)	<LOD	0.11^{E} (<LOD - 0.17)	0.28^{E} (0.14 - 0.42)	0.84^{E} (0.42 - 1.3)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 13.6.2

Perfluoroundecanoic acid (PFUnDA) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by sex and age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79	2	765	40.39	—	<LOD	0.094 (<LOD - 0.11)	0.19 (0.13 - 0.24)	0.47^{E} (0.27 - 0.67)
Males, 12–19	2	254	60.63	—	<LOD	<LOD	0.098 (<LOD - 0.13)	0.32 (0.23 - 0.42)
Males, 20–39	2	170	38.24	0.11 (<LOD - 0.14)	<LOD	0.092^{E} (<LOD - 0.13)	0.18 (0.11 - 0.24)	x
Males, 40–59	2	176	28.98	0.12 (0.094 - 0.16)	<LOD	0.097^{E} (<LOD - 0.13)	0.19^{E} (0.091 - 0.29)	x
Males, 60–79	2	165	23.64	0.15^{E} (0.10 - 0.23)	<LOD	0.12^{E} (<LOD - 0.20)	0.32^{E} (0.16 - 0.48)	x
Females, Total 12–79	2	757	38.18	0.12 (0.10 - 0.15)	<LOD	0.096 (<LOD - 0.11)	0.18 (0.13 - 0.23)	0.63^{E} (0.24 - 1.0)
Females, 12–19	2	252	55.95	—	<LOD	<LOD	0.098 (<LOD - 0.12)	0.24 (0.16 - 0.33)
Females, 20–39	2	192	35.94	0.15 (0.12 - 0.20)	<LOD	0.12 (<LOD - 0.16)	0.26^{E} (0.15 - 0.37)	x
Females, 40–59	2	158	23.42	0.11 (<LOD - 0.13)	<LOD	0.095 (<LOD - 0.11)	0.12^{E} (<LOD - 0.18)	x
Females, 60–79	2	155	27.10	0.14^{E} (<LOD - 0.24)	<LOD	0.10^{E} (<LOD - 0.17)	0.24^{E} (<LOD - 0.39)	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act.*

13.7 PERFLUOROBUTANE SULFONATE (PFBS)

■ Table 13.7.1

Perfluorobutane sulfonate (PFBS) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79	2	1524	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	507	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	362	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	334	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	321	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

■ Table 13.7.2

Perfluorobutane sulfonate (PFBS) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by sex and age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79	2	765	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	170	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	176	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	165	100	—	<LOD	<LOD	<LOD	x
Females, Total 12–79	2	759	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	253	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	192	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	158	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	156	100	—	<LOD	<LOD	<LOD	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

13.8 PERFLUOROHEXANE SULFONATE (PFHxS)

Table 13.8.1

Perfluorohexane sulfonate (PFHxS) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 20–79	1	2880	2.05	2.3 (2.0 - 2.6)	0.70 (0.50 - 0.89)	2.2 (1.8 - 2.5)	3.7 (3.2 - 4.1)	12 (9.2 - 15)
Total, 20–79	2	1015	1.38	1.7 (1.6 - 2.0)	0.55 (0.44 - 0.65)	1.7 (1.5 - 1.9)	2.7 (2.0 - 3.4)	8.9[E] (4.6 - 13)
Males, Total 20–79	1	1376	0.58	3.2 (2.8 - 3.7)	1.3 (1.1 - 1.6)	2.8 (2.4 - 3.2)	4.6 (4.0 - 5.2)	16 (11 - 20)
Males, Total 20–79	2	510	0.59	2.4 (2.0 - 2.8)	0.94 (0.76 - 1.1)	2.1 (1.9 - 2.4)	3.6 (2.7 - 4.5)	9.4[E] (4.9 - 14)
Females, Total 20–79	1	1504	3.39	1.6 (1.4 - 1.9)	0.50 (0.38 - 0.62)	1.5 (1.2 - 1.7)	2.7 (2.3 - 3.1)	8.5 (6.6 - 10)
Females, Total 20–79	2	505	2.18	1.3 (1.1 - 1.5)	0.40 (0.34 - 0.45)	1.2 (1.0 - 1.3)	2.0 (1.6 - 2.4)	8.2[E] (3.4 - 13)

a For the purpose of total population comparisons, only values from participants aged 20–79 years were included as participants under the age of 20 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 13.8.2

Perfluorohexane sulfonate (PFHxS) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and Cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79[b]	1							
Total, 12–79	2	1521	1.25	1.8 (1.6 - 2.0)	0.55 (0.46 - 0.64)	1.7 (1.5 - 1.9)	2.8 (2.2 - 3.5)	9.0[E] (4.9 - 13)
12–19[b]	1							
12–19	2	506	0.99	1.9 (1.6 - 2.3)	0.60 (0.50 - 0.70)	1.6 (1.3 - 1.9)	3.4 (2.3 - 4.5)	11[E] (5.7 - 16)
20–39	1	979	3.06	2.1 (1.8 - 2.4)	0.61 (0.49 - 0.73)	1.9 (1.5 - 2.2)	3.6 (3.2 - 3.9)	16[E] (10 - 23)
20–39	2	361	1.94	1.5 (1.3 - 1.9)	0.41 (0.28 - 0.54)	1.6 (1.1 - 2.1)	2.5[E] (1.5 - 3.5)	6.0[E] (2.1 - 9.9)
40–59	1	983	2.03	2.2 (1.9 - 2.5)	0.79 (0.54 - 1.0)	2.2 (1.8 - 2.5)	3.6 (3.0 - 4.2)	9.2 (7.4 - 11)
40–59	2	333	1.80	1.8 (1.4 - 2.3)	0.58[E] (0.33 - 0.83)	1.7 (1.3 - 2.0)	2.6[E] (1.5 - 3.6)	12[E] (3.5 - 21)
60–79	1	918	0.98	2.8 (2.4 - 3.3)	1.1 (0.90 - 1.3)	2.6 (2.1 - 3.0)	4.3 (3.5 - 5.1)	13 (9.0 - 16)
60–79	2	321	0.31	2.2 (1.8 - 2.7)	0.86 (0.64 - 1.1)	2.0 (1.6 - 2.4)	3.4 (2.4 - 4.4)	9.8 (6.7 - 13)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 20 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 13.8.3

Perfluorohexane sulfonate (PFHxS) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by sex and age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79[b]	1							
Males, Total 12–79	2	763	0.66	2.4 (2.0 - 2.7)	0.92 (0.82 - 1.0)	2.1 (1.9 - 2.4)	3.6 (2.8 - 4.5)	9.9[E] (5.5 - 14)
Males, 12–19[b]	1							
Males, 12–19	2	253	0.79	2.2 (1.8 - 2.8)	0.69 (0.49 - 0.90)	1.9 (1.3 - 2.4)	4.1[E] (2.3 - 5.9)	F
Males, 20–39	1	435	0.23	3.3 (2.7 - 4.1)	1.2 (0.89 - 1.6)	2.8 (2.3 - 3.2)	4.7 (3.3 - 6.1)	F
Males, 20–39	2	169	0.59	2.4 (1.9 - 3.1)	0.91 (0.72 - 1.1)	2.1 (1.6 - 2.7)	3.7[E] (2.2 - 5.3)	x
Males, 40–59	1	480	0.42	3.3 (2.8 - 3.8)	1.4 (1.1 - 1.7)	2.9 (2.4 - 3.4)	4.7 (3.4 - 6.0)	11[E] (5.3 - 16)
Males, 40–59	2	176	1.14	2.2 (1.9 - 2.6)	1.2 (0.85 - 1.5)	2.2 (1.9 - 2.4)	3.0 (2.1 - 3.9)	x
Males, 60–79	1	461	1.08	3.0 (2.5 - 3.5)	1.2 (0.94 - 1.4)	2.8 (2.2 - 3.3)	4.3 (3.6 - 5.0)	12 (8.7 - 16)
Males, 60–79	2	165	0	2.4 (2.0 - 3.0)	0.92 (0.69 - 1.2)	2.2 (1.7 - 2.6)	3.8 (2.5 - 5.0)	x
Females, Total 12–79[b]	1							
Females, Total 12–79	2	758	1.85	1.3 (1.1 - 1.5)	0.41 (0.36 - 0.46)	1.2 (1.0 - 1.3)	2.1 (1.7 - 2.4)	8.5[E] (3.7 - 13)
Females, 12–19[b]	1							
Females, 12–19	2	253	1.19	1.6 (1.2 - 2.0)	0.54 (0.41 - 0.68)	1.2 (0.89 - 1.6)	2.4[E] (1.4 - 3.4)	9.0[E] (3.5 - 14)
Females, 20–39	1	544	5.33	1.3 (1.1 - 1.6)	0.37[E] (<LOD - 0.56)	1.2 (1.0 - 1.3)	2.1 (1.5 - 2.8)	8.0[E] (4.2 - 12)
Females, 20–39	2	192	3.13	0.86 (0.68 - 1.1)	0.25[E] (<LOD - 0.42)	0.99 (0.86 - 1.1)	1.3 (0.97 - 1.7)	x
Females, 40–59	1	503	3.58	1.5 (1.3 - 1.8)	0.47 (0.32 - 0.62)	1.4 (1.1 - 1.7)	2.5 (2.1 - 2.9)	6.6 (4.9 - 8.4)
Females, 40–59	2	157	2.55	1.5[E] (0.95 - 2.3)	0.51 (0.34 - 0.69)	1.1 (0.78 - 1.5)	F	x
Females, 60–79	1	457	0.88	2.7 (2.2 - 3.3)	1.0 (0.78 - 1.3)	2.3 (1.9 - 2.8)	4.0 (2.7 - 5.2)	13[E] (6.9 - 19)
Females, 60–79	2	156	0.64	2.0 (1.5 - 2.6)	0.68[E] (0.27 - 1.1)	1.9 (1.3 - 2.4)	3.2 (2.2 - 4.3)	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 20 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

13.9 PERFLUOROOCTANE SULFONATE (PFOS)

Table 13.9.1

Perfluorooctane sulfonate (PFOS) — Geometric means and selected percentiles of plasma concentrations (μg/L) for the Canadian population aged 20–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 20–79	1	2880	0.14	8.9 (8.0 - 9.8)	3.6 (3.1 - 4.1)	9.1 (8.1 - 10)	13 (12 - 15)	27 (22 - 32)
Total, 20–79	2	1017	0.39	6.9 (6.2 - 7.6)	2.6 (1.9 - 3.2)	6.8 (6.0 - 7.6)	11 (9.5 - 12)	19 (13 - 25)
Males, Total 20–79	1	1376	0.07	11 (10 - 12)	5.1 (4.3 - 6.0)	11 (9.5 - 12)	16 (14 - 18)	31 (23 - 39)
Males, Total 20–79	2	511	0.39	8.3 (7.4 - 9.3)	4.7 (3.6 - 5.8)	8.2 (6.6 - 9.8)	12 (9.9 - 14)	19 (14 - 25)
Females, Total 20–79	1	1504	0.20	7.1 (6.3 - 7.9)	3.0 (2.6 - 3.4)	7.4 (6.4 - 8.4)	11 (9.6 - 12)	20 (15 - 24)
Females, Total 20–79	2	506	0.40	5.7 (4.9 - 6.6)	2.0 (1.5 - 2.4)	6.0 (5.1 - 6.9)	9.0 (7.1 - 11)	19[E] (7.8 - 30)

a For the purpose of total population comparisons, only values from participants aged 20–79 years were included as participants under the age of 20 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 13.9.2

Perfluorooctane sulfonate (PFOS) — Geometric means and selected percentiles of plasma concentrations (μg/L) for the Canadian population aged 12–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and Cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 12–79[b]	1							
Total, 12–79	2	1524	0.33	6.5 (5.9 - 7.2)	2.4 (2.0 - 2.8)	6.7 (6.1 - 7.3)	10 (9.3 - 11)	18 (13 - 23)
12–19[b]	1							
12–19	2	507	0.20	4.6 (4.0 - 5.2)	2.1 (1.9 - 2.4)	4.6 (3.9 - 5.3)	6.6 (5.7 - 7.5)	11 (9.2 - 13)
20–39	1	979	0.10	8.2 (7.2 - 9.3)	3.5 (2.8 - 4.1)	8.6 (7.3 - 9.9)	12 (11 - 14)	21 (19 - 24)
20–39	2	362	0.55	6.2 (5.4 - 7.1)	2.1[E] (0.99 - 3.2)	6.7 (5.8 - 7.6)	10 (7.4 - 13)	19[E] (9.6 - 29)
40–59	1	983	0.31	8.6 (7.7 - 9.5)	3.4 (2.8 - 4.0)	8.8 (7.9 - 9.7)	13 (11 - 15)	28 (19 - 37)
40–59	2	334	0.60	6.4 (5.7 - 7.2)	2.3 (1.6 - 3.0)	6.7 (5.7 - 7.7)	10 (8.7 - 11)	16 (13 - 19)
60–79	1	918	0	11 (9.6 - 13)	4.4 (3.3 - 5.5)	11 (9.6 - 13)	17 (14 - 19)	30 (24 - 35)
60–79	2	321	0	9.4 (8.3 - 11)	4.6 (3.9 - 5.3)	9.8 (8.1 - 11)	15 (13 - 16)	21[E] (7.5 - 35)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 20 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 13.9.3

Perfluorooctane sulfonate (PFOS) — Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79 years by sex and age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 12–79[b]	1							
Males, Total 12–79	2	765	0.26	7.8 (7.1 - 8.7)	3.8 (2.8 - 4.8)	7.6 (6.3 - 9.0)	11 (9.8 - 13)	19 (14 - 24)
Males, 12–19[b]	1							
Males, 12–19	2	254	0	5.1 (4.6 - 5.7)	2.4 (2.1 - 2.6)	5.2 (4.6 - 5.7)	7.1 (6.0 - 8.3)	13[E] (7.5 - 18)
Males, 20–39	1	435	0	10 (9.2 - 12)	5.3 (4.3 - 6.2)	10 (9.2 - 11)	14 (13 - 16)	27 (20 - 35)
Males, 20–39	2	170	0.59	8.2 (6.8 - 10)	4.8 (4.1 - 5.4)	7.6[E] (4.7 - 11)	12 (8.9 - 14)	x
Males, 40–59	1	480	0.21	11 (10 - 13)	5.0 (4.0 - 6.0)	11 (9.1 - 12)	16 (14 - 18)	34 (22 - 46)
Males, 40–59	2	176	0.57	7.5 (6.7 - 8.4)	3.2[E] (1.8 - 4.7)	7.6 (6.7 - 8.5)	10 (9.2 - 12)	x
Males, 60–79	1	461	0	12 (10 - 14)	5.0[E] (3.0 - 6.9)	12 (9.5 - 14)	18 (14 - 22)	35 (23 - 46)
Males, 60–79	2	165	0	10 (8.9 - 12)	4.7 (3.4 - 6.0)	11 (7.9 - 14)	15 (13 - 17)	x
Females, Total 12–79[b]	1							
Females, Total 12–79	2	759	0.40	5.5 (4.8 - 6.2)	2.0 (1.6 - 2.3)	5.7 (4.8 - 6.5)	8.4 (6.8 - 10)	18[E] (9.7 - 27)
Females, 12–19[b]	1							
Females, 12–19	2	253	0.40	4.1 (3.4 - 4.8)	2.0 (1.7 - 2.3)	4.0 (3.2 - 4.8)	6.1 (5.0 - 7.3)	9.0 (7.3 - 11)
Females, 20–39	1	544	0.18	6.4 (5.4 - 7.5)	3.0 (2.6 - 3.4)	6.4 (5.1 - 7.7)	9.8 (7.7 - 12)	16 (14 - 19)
Females, 20–39	2	192	0.52	4.4 (3.5 - 5.6)	1.6[E] (0.97 - 2.3)	4.3 (2.9 - 5.8)	6.7 (5.8 - 7.7)	x
Females, 40–59	1	503	0.40	6.5 (5.8 - 7.3)	2.8 (2.2 - 3.3)	6.9 (6.0 - 7.9)	9.9 (9.3 - 11)	17 (12 - 22)
Females, 40–59	2	158	0.63	5.6 (4.6 - 6.8)	2.2[E] (1.4 - 3.0)	6.2 (4.5 - 7.9)	9.3 (6.6 - 12)	x
Females, 60–79	1	457	0	10 (8.6 - 12)	4.1 (3.0 - 5.1)	10 (8.8 - 12)	15 (12 - 17)	27 (22 - 31)
Females, 60–79	2	156	0	8.8 (7.2 - 11)	4.3 (2.9 - 5.6)	8.4 (5.5 - 11)	14 (9.9 - 18)	x

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 20 years were not included in cycle 1 (2007–2009).

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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PESTICIDE SUMMARIES AND RESULTS

14

14.1 ATRAZINE METABOLITES

Atrazine (CASRN 1912-24-9) is a synthetic selective herbicide registered for use in Canada for the control of annual broadleaf weeds and grassy weeds in corn (Health Canada, 2003; Health Canada, 2004). It belongs to a group of pesticides known as triazine herbicides that also includes simazine, propazine, and cyanazine (Barr & Needham, 2002; IPCS, 1997). Triazine herbicides were first produced in 1958, and atrazine was introduced into Canada in 1960 (ATSDR, 2003; CCME, 1999). The use of atrazine has decreased significantly in recent years because of environmental concerns; its use is now half of that of 1983 (CCME, 2009; Health Canada, 2003). The following atrazine metabolites were measured as part of this survey: diaminochlorotriazine (DACT; CASRN 3397-62-4), desethylatrazine (DEA; CASRN 6190-65-4), and atrazine mercapturate (AM; CASRN 138722-96-0).

Atrazine is released to the environment as a result of agricultural practices. It is mobile in soil and may enter groundwater through percolation and surface water via direct runoff (ATSDR, 2003; Health Canada, 2007). In the environment, atrazine undergoes dealkylation forming various metabolites, including DEA and DACT (Nelson et al., 2001). Atrazine and its dealkylated metabolites have been found in surface water and groundwater following application of atrazine (WHO, 2009). In areas where atrazine is used extensively, it is one of the most frequently detected pesticides in surface and well water (Health Canada, 1993). Atrazine exposure in the general population occurs primarily through water or air and, in rare instances, food (ATSDR, 2003).

Atrazine is well absorbed orally, metabolized, and then eliminated in the urine over a few days (CDC, 2009). Following absorption, atrazine is metabolized via the glutathione detoxification pathway into mercapturic acid metabolites, such as AM, and via simple dealkylation into dealkylated metabolites, such as DEA and DACT (Barr & Needham, 2002; Barr et al., 2007). In human studies, DACT and AM have been identified as primary metabolites (Barr et al., 2007; Catenacci et al., 1993; Lucas et al., 1993). Dealkylated metabolites are not specific to atrazine and can result from the metabolism of other triazine herbicides such as simazine, propazine, and cyanazine (Barr & Needham, 2002; CDC, 2009; Mendas et al., 2012). These metabolites can be measured in urine and are reflective of recent exposure to triazine herbicides (including atrazine) or the metabolites in the environment (ATSDR, 2003). Atrazine has also been directly measured in urine, but only constituted less than 2% of excreted metabolites (80% were dealkylated metabolites), and therefore is not a good biomarker for exposure (Catenacci et al., 1993). AM is a metabolite specific to atrazine, and urinary levels are a specific biomarker of recent atrazine exposure (CDC, 2009; Mendas et al., 2012).

The bulk of the available toxicity data comes from long-term oral exposure in animals (ATSDR, 2003). In animals, reduced body weight gain, cardiotoxicity, developmental effects, reproductive effects, and neuroendocrine effects have been reported following oral exposure to both atrazine and its dealkylated metabolites (ATSDR, 2006; CDC, 2009; Health Canada, 1993; Health Canada, 2003; WHO, 2011). In humans, nausea and dizziness have been associated with ingestion of an unspecified concentration of atrazine in drinking water (Health Canada, 1993).

Atrazine is not genotoxic and not classifiable as to its carcinogenicity to humans (Group 3) according to the International Agency for Research on Cancer (CDC, 2009; IARC, 1999; WHO, 2009).

The sale and use of atrazine and other triazine herbicides is regulated in Canada under the *Pest Control Products Act* by the Pest Management Regulatory Agency (PMRA) (Canada, 2006). PMRA completed a re-evaluation of the human health risks related to atrazine in 2004 and determined that all uses of atrazine and its end-use products were not of concern to human health, provided that the proposed mitigation measures were implemented (Health Canada, 2003; Health Canada, 2004). These mitigation measures include a phase-out of use in lowbush blueberries, atrazine-tolerant canola, and in industrial and residential settings (Health Canada, 2003). Health Canada has established maximum residue limits for atrazine in various foods and set an acceptable daily intake for atrazine plus its chlorinated metablites (Health Canada, 2003; Health Canada, 2011). Health Canada has also established a Canadian drinking water quality guideline that sets out the maximum acceptable concentration of the sum of atrazine and its dealkylated metabolites (Health Canada, 1993; Health Canada, 2007; Health Canada, 2012).

There are no existing biomonitoring data on concentrations of atrazine in the Canadian population.

Atrazine metabolites (AM, DACT, and DEA) were measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and are presented as both µg/L and µg/g creatinine (Tables 14.1.1.1 to 14.1.3.4). Finding a measurable amount of atrazine metabolites in urine is an indicator of exposure to atrazine and/or other triazine herbicides and their metabolites in the environment and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary atrazine metabolite levels in the Canadian population.

14.1.1 Atrazine Mercapturate (AM)

Table 14.1.1.1

Atrazine mercapturate (AM) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2526	99.88	—	<LOD	<LOD	<LOD	<LOD
3–5	2	508	99.80	—	<LOD	<LOD	<LOD	<LOD
6–11	2	511	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	506	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	355	99.72	—	<LOD	<LOD	<LOD	<LOD
40–59	2	359	99.72	—	<LOD	<LOD	<LOD	<LOD
60–79	2	287	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.1.1.2

Atrazine mercapturate (AM) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1268	99.92	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	261	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	166	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	99.48	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1258	99.84	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	250	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	251	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	99.47	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	166	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	145	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.1.1.3

Atrazine mercapturate (AM) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2516	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	507	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	509	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	504	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	353	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	357	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	286	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.1.1.4

Atrazine mercapturate (AM) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1264	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	260	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	165	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	99.48	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1252	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	249	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	250	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	188	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	164	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	144	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.1.2 Diaminochlorotriazine (DACT)

Table 14.1.2.1

Diaminochlorotriazine (DACT) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2526	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	508	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	511	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	506	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	355	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	359	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	287	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.1.2.2

Diaminochlorotriazine (DACT) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1268	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	261	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	166	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1258	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	250	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	251	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	166	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	145	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.1.2.3

Diaminochlorotriazine (DACT) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2516	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	507	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	509	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	504	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	353	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	357	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	286	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.1.2.4

Diaminochlorotriazine (DACT) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1264	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	260	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	165	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1252	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	249	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	250	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	188	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	164	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	144	100	—	<LOD	<LOD	<LOD	x

[a] Breakdown by sex for the 3–5 year old age group is not recommended.

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.1.3 Desethylatrazine (DEA)

Table 14.1.3.1

Desethylatrazine (DEA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2526	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	508	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	511	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	506	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	355	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	359	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	287	100	—	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.1.3.2

Desethylatrazine (DEA) — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1268	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	261	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	166	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1258	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	250	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	251	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	166	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	145	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.1.3.3

Desethylatrazine (DEA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (μg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2516	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	507	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	509	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	504	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	353	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	357	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	286	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.1.3.4

Desethylatrazine (DEA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1264	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	260	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	165	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1252	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	249	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	250	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	188	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	164	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	144	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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14.2 CARBAMATE METABOLITES

N-Methyl carbamate insecticides, commonly known as carbamates, are a group of synthetic pesticides (Health Canada, 2010; IPCS, 1986). Carbamate insecticides were first introduced in the 1950s as replacements for organochlorine pesticides because they are less persistent in the environment and do not bioaccumulate (Rawn et al., 2004; WHO, 2004). The use of carbamates in Canada has decreased since the mid-1990s with the introduction of pyrethroids and other replacement insecticides (Rawn et al., 2006).

The following carbamate metabolites were measured as part of this survey: carbofuranphenol (CASRN 1563-38-8), 2-isopropoxyphenol (CASRN 4812-20-8), and 1-hydroxynaphthalene (CASRN 90-15-3).

Carbofuranphenol is a metabolite of the carbamate insecticide carbofuran and its derivatives, namely benfuracarb, carbosulfan, and furathiocarb (Kawamoto & Makihata, 2003). In Canada, only carbofuran is currently registered for use; benfuracarb, furathiocarb, and carbosulfan have never been registered for use in Canada (Health Canada, 2009a; Health Canada, 2012a). Carbofuran is used in Canada to control a broad range of insect pests on field, vegetable, and fruit crops primarily by farmers, farmworkers, and professional applicators (Health Canada, 2010; Rawn et al., 2004).

2-Isopropoxyphenol is a specific metabolite of propoxur that has been used internationally as a replacement for dichlorodiphenyltrichloroethane, or DDT, in malaria-vector control (Metcalfe, 1995). In Canada, propoxur is registered under the *Pest Control Products Act* to control a wide range of insect and arthropod pests (Canada, 2006; Health Canada, 2011a). It is used in and on commercial, industrial, institutional, and residential structures, in transportation vehicles, at outdoor residential sites, on companion animals, and in human habitats and recreational sites (Health Canada, 2011a).

1-Hydroxynaphthalene is a metabolite of the carbamate insecticide carbaryl as well as the polycyclic aromatic hydrocarbon naphthalene, making it difficult to distinguish between these exposures in the general population (Meeker et al., 2007). For information on 1-hydroxynaphthalene, as well as related data tables, see section 16.6 (Naphthalene Metabolites). Carbaryl is a broad spectrum insecticide and a plant growth regulator currently registered for use in agricultural, industrial, forest, and residential areas (Health Canada, 2009b). In Canada, carbaryl is registered for use as an insecticide on food and feed crops, ornamental crops, livestock, forestry sites, industrial sites, as well as commercial turf such as that found on golf courses and sod farms. It is also registered as a plant growth regulator used for apple thinning (Health Canada, 2009b).

Exposure of the general population to carbamates can occur through dermal contact when handling and applying insecticides (EPA, 2012). Although exposure to carbamates can also occur through ingestion of residues present in food and drinking water, this exposure route is less common because residues in treated crops are generally very low (EPA, 2012; Health Canada, 2010).

Carbamates are generally easily absorbed through the skin, mucous membranes, and respiratory and gastrointestinal tracts of mammals (IPCS, 1986). In humans, they are rapidly absorbed, metabolized, and eliminated mainly in urine (IPCS, 1986; WHO, 2004). Urinary levels of carbofuranphenol, 2-isopropoxyphenol, and 1-hydroxynaphthalene reflect recent exposure (CDC, 2009).

Like organophosphates, carbamates inhibit acetylcholinesterase, a key enzyme involved in terminating nerve pulses by degrading the neurotransmitter acetylcholine into the inactive products choline and acetic acid (Fukuto, 1990; IPCS, 1986; Leibson & Lifshitz, 2008; Sogorb & Vilanova, 2002). Carbamates do not require metabolic activation and inhibit acetylcholinesterase by depositing a carbamyl group on the enzyme (Fukuto, 1990; IPCS, 1986; Leibson & Lifshitz, 2008). This interrupts the transmission of nerve impulses and overstimulates the nervous system (IPCS, 1986). An important aspect of carbamate toxicity is the rapid nature of the onset following inhibition of acetylcholinesterase and recovery of effects (EPA, 2007). Acute exposure to high concentrations of carbamates in animals has resulted in salivation, shedding of tears, constriction of pupils, urination, respiratory difficulties, muscular twitching, tremors, cramps, and ataxia (Health Canada, 2009a; IPCS, 1986; WHO, 2004).

Adverse health effects observed in humans following short- and long-term exposure include nausea, dizziness, vomiting, headache, sweating, salivation, ataxia, confusion, and breathing difficulties (Health Canada, 2009a; IPCS, 1986). In severe cases, acute toxicity from carbamate exposure can cause potentially fatal respiratory failure (IPCS, 1986). Carbamate metabolites are generally less toxic than their parent compounds (IPCS, 1986). According to the International Agency for Research on Cancer (IARC), carbaryl is not classifiable as to its carcinogenicity to humans (Group 3), whereas naphthalene is possibly carcinogenic to humans (Group 2B) (IARC, 1987; IARC, 2002). Neither carbofuran nor propoxur has been classified by IARC.

The sale and use of carbamate insecticides is regulated in Canada under the *Pest Control Products Act* by the Pest Management Regulatory Agency (PMRA) (Canada, 2006). In 2002, PMRA initiated a re-evaluation of all *N*-methyl carbamate active ingredients used in Canada, including carbofuran, carbaryl, and propoxur (Health Canada, 2002). As a result of the re-evaluation, PMRA required phase out of carbofuran products because, under current conditions of use, they pose an unacceptable risk to human health and the environment (Health Canada, 2010). Human health concerns were identified for both occupational and dietary carbofuran exposure (Health Canada, 2010). PMRA has also recently proposed the phase out of certain propoxur uses in Canada, including control of biting flies, pet collars, and all indoor uses of domestic-class products except bait trays (Health Canada, 2011a). It is proposed that propoxur continue to be allowed for commercial use in indoor crack and crevice applications, for domestic and commercial outdoor uses, and for bait trays (Health Canada, 2011a). Certain carbaryl uses in Canada were also proposed for phase out; these uses include turf and residential uses, as well as some agricultural uses (Health Canada, 2009b).

Maximum residue limits have been established in some foods for certain carbamates that have registered food uses (Health Canada, 2010; Health Canada, 2011b; Rawn et al., 2004; Rawn et al., 2006). However, in its recent re-evaluation, PMRA requires that all maximum residue limits for carbofuran be amended or revoked (Health Canada, 2010; Health Canada, 2012b). Health Canada has also set an acceptable daily intake for carbofuran and proposed acceptable daily intakes for propoxur and carbaryl (Health Canada, 2009b; Health Canada, 2010; Health Canada, 2011a). Health Canada has established Canadian drinking water quality guidelines that set out the maximum acceptable concentrations of carbofuran and carbaryl (Health Canada, 2012b). A maximum acceptable concentration has not been established for propoxur.

Carbamate metabolites (carbofuranphenol, 2-isopropoxyphenol and 1-hydroxynaphthalene) were measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years. Data for carbofuranphenol and 2-isopropoxyphenol are presented below as both µg/L and µg/g creatinine (Tables 14.2.1.1 to 14.2.2.4). See section 16.6 (Naphthalene Metabolites) for 1-hydroxynaphthalene data tables. Finding a measurable amount of carbamate metabolites in urine can be an indicator of exposure to carbamates and does not necessarily mean that an adverse health effect will occur. These data provide baseline urinary levels for carbofuranphenol, 2-isopropoxyphenol and 1-hydroxynaphthalene in the Canadian population.

14.2.1 Carbofuranphenol

Table 14.2.1.1

Carbofuranphenol — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2557	99.96	—	<LOD	<LOD	<LOD	<LOD
3–5	2	522	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	516	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	511	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	357	99.72	—	<LOD	<LOD	<LOD	<LOD
40–59	2	360	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	291	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.2.1.2

Carbofuranphenol — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1279	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	262	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	256	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	167	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	194	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1278	99.92	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	255	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	190	99.47	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	166	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	149	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.2.1.3

Carbofuranphenol (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2547	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	521	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	514	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	509	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	355	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	358	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	290	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.2.1.4

Carbofuranphenol (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1275	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	261	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	166	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	194	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1272	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	253	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	164	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	148	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.2.2 2-Isopropoxyphenol

Table 14.2.2.1

2-Isopropoxyphenol — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2560	99.80	—	<LOD	<LOD	<LOD	<LOD
3–5	2	524	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	516	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	512	99.41	—	<LOD	<LOD	<LOD	<LOD
20–39	2	357	99.44	—	<LOD	<LOD	<LOD	<LOD
40–59	2	360	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	291	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.2.2.2

2-Isopropoxyphenol — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1281	99.69	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	262	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	256	99.22	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	167	98.80	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	194	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1279	99.92	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	256	99.61	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	190	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	166	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	149	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.2.2.3

2-Isopropoxyphenol (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2550	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	523	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	514	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	510	99.80	—	<LOD	<LOD	<LOD	<LOD
20–39	2	355	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	358	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	290	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.2.2.4

2-Isopropoxyphenol (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1277	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	261	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	99.61	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	166	99.40	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	194	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1273	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	253	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	255	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	164	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	148	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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14.3 2,4-DICHLOROPHENOXYACETIC ACID (2,4-D)

The pesticide 2,4-dichlorophenoxyacetic acid (2,4-D) is the most commonly used chemical in the class of phenoxy herbicides. It is a selective synthetic herbicide used for the control of broadleaf weeds in residential, agricultural, and forest environments. 2,4-D was first registered in Canada in 1946 for agricultural and forestry use and has been permitted for use on lawns and turf since the 1960s. 2,4-D is found in over 150 agricultural and residential products in Canada and is often combined with other herbicides and fertilizers (Health Canada, 2012).

2,4-D is a relatively short-lived chemical in terrestrial and aquatic environments, with a half-life of less than 2 weeks, except in anaerobic environments where 2,4-D is persistent (Health Canada, 2007). This highly mobile chemical is susceptible to leaching and runoff from treated areas (Health Canada, 2007).

The primary routes of exposure for the general public are through ingestion of food and drinking water, handling 2,4-D-containing products, and environmental exposure in herbicide-treated areas (Health Canada, 2008).

Following entry into the body, 2,4-D is rapidly absorbed and excreted primarily unchanged in urine (Sauerhoff et al., 1977). Accumulation in tissues is low because 2,4-D has an elimination half-life of 10 to 33 hours (Sauerhoff et al., 1977). 2,4-D has been routinely measured in urine; its presence is proportional to the previous few days of exposure. 2,4-D has been measured in other biological matrices including semen and plasma (Arbuckle et al., 1999; Barr & Needham, 2002).

Long-term exposure to 2,4-D has been associated with effects on the kidneys, nervous system, and body weights in animal studies; the primary target organ for toxicity is the kidney (Health Canada, 2007). Some studies have suggested associations between occupational use of phenoxy herbicides and cancer, including non-Hodgkin's lymphoma and soft tissue sarcomas. However, these studies are complicated by confounding factors and exposures to other pesticides or impurities, and other studies have not shown an association (ATSDR, 1999; Health Canada, 2008; IARC, 1987; IARC, 1999; WHO, 2003a; WHO, 2003b). Recent re-evaluations by the Canadian Pest Management Regulatory Agency (PMRA), the European Union, the United States Environmental Protection Agency, and the World Health Organization did not classify 2,4-D as a human carcinogen (EPA, 2005; European Commission, 2001; Health Canada, 2006; WHO, 2003a).

The sale and use of 2,4-D is regulated in Canada under the *Pest Control Products Act* by PMRA (Canada, 2006). PMRA evaluates the toxicity of pesticides and potential exposure in order to determine whether a pesticide should be registered for a specific use. In the most recent re-evaluation by PMRA in 2008, it was determined that there were no unacceptable health risks posed to the public from products containing 2,4-D. As part of the registration process, PMRA has established maximum residue limits for 2,4-D in various foods (Health Canada, 2011). Many municipalities and provinces have imposed further restrictions or bans on the use of 2,4-D on lawns to address local concerns regarding the use of pesticides for cosmetic or aesthetic purposes.

Health Canada has set an acceptable daily intake for 2,4-D and established a Canadian drinking water quality guideline that sets out an interim maximum acceptable concentration for 2,4-D (Health Canada, 1993; Health Canada, 2007; Health Canada, 2008; WHO, 2003a).

In 1996, 2,4-D was measured in 24-hour urine samples from Ontario farmers and farm families as part of the Ontario Farm Family Health Study and the Pesticide Exposure Assessment Pilot Study. In the farmers, mean urinary concentrations were 26.6 µg/L (Arbuckle et al., 1999). Geometric mean urinary concentrations ranged from 0.7 to 9.9 µg/L in farm applicators, 0.55 to 0.66 µg/L in women, and 0.7 to 2.9 µg/L in children aged 3 to 18 years (Arbuckle et al., 2004; Arbuckle et al., 2005; Arbuckle & Ritter, 2005). Urinary levels of 2,4-D were measured in morning voids from 123 children aged 3 to 7 years in the province of Quebec in 2003. Only six samples had detectable levels, with a geometric mean and maximum of 13.9 µg/g creatinine and 40 µg/g creatinine, respectively (INSPQ, 2004).

2,4-D was measured in the urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented as both µg/L (Tables 14.3.1, 14.3.2, and 14.3.3) and µg/g creatinine (Tables 14.3.4, 14.3.5, and 14.3.6). Finding a measurable amount of 2,4-D in urine is an indicator of exposure to 2,4-D and does not necessarily mean that an adverse health effect will occur.

Table 14.3.1

2,4-Dichlorophenoxyacetic acid (2,4-D) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5480	58.10	—	<LOD	<LOD	0.29 (0.21 - 0.36)	0.91 (0.73 - 1.1)
Total, 6–79	2	2028	43.44	—	<LOD	0.22 (<LOD - 0.26)	0.40 (0.34 - 0.45)	1.0 (0.86 - 1.2)
Males, Total 6–79	1	2661	55.20	—	<LOD	<LOD	0.33 (0.25 - 0.40)	1.0 (0.71 - 1.3)
Males, Total 6–79	2	1016	37.20	0.26 (0.22 - 0.30)	<LOD	0.24 (0.21 - 0.28)	0.46 (0.37 - 0.55)	1.2 (0.96 - 1.5)
Females, Total 6–79	1	2819	60.84	—	<LOD	<LOD	0.26 (<LOD - 0.34)	0.75 (0.63 - 0.87)
Females, Total 6–79	2	1012	49.70	—	<LOD	<LOD	0.34 (0.28 - 0.40)	0.80 (0.56 - 1.0)

[a] For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.3.2

2,4-Dichlorophenoxyacetic acid (2,4-D) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2551	41.98	—	<LOD	0.22 (<LOD - 0.26)	0.40 (0.35 - 0.45)	1.0 (0.87 - 1.2)
3–5[b]	1							
3–5	2	523	36.33	0.26 (0.23 - 0.30)	<LOD	0.26 (0.20 - 0.31)	0.46 (0.37 - 0.55)	1.1 (0.81 - 1.4)
6–11	1	1030	57.48	—	<LOD	<LOD	0.32 (0.22 - 0.42)	0.92 (0.66 - 1.2)
6–11	2	512	42.38	—	<LOD	0.26 (0.22 - 0.30)	0.45 (0.38 - 0.53)	1.2^{E} (0.78 - 1.7)
12–19	1	981	56.17	—	<LOD	<LOD	0.30^{E} (<LOD - 0.41)	0.75 (0.66 - 0.84)
12–19	2	511	41.68	—	<LOD	0.23 (<LOD - 0.26)	0.40 (0.30 - 0.50)	0.98 (0.73 - 1.2)
20–39	1	1166	61.66	—	<LOD	<LOD	0.26 (<LOD - 0.33)	0.73 (0.55 - 0.90)
20–39	2	357	46.22	—	<LOD	0.21 (<LOD - 0.25)	0.34 (0.26 - 0.41)	0.69^{E} (0.34 - 1.0)
40–59	1	1222	60.31	—	<LOD	<LOD	0.28 (0.20 - 0.36)	0.99 (0.64 - 1.3)
40–59	2	357	43.70	—	<LOD	0.24 (<LOD - 0.32)	0.42 (0.32 - 0.51)	1.1 (0.77 - 1.4)
60–79	1	1081	54.12	—	<LOD	<LOD	0.36 (0.30 - 0.43)	1.1^{E} (0.72 - 1.6)
60–79	2	291	44.67	—	<LOD	<LOD	0.43 (0.29 - 0.56)	1.2^{E} (0.54 - 1.9)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 14.3.3

2,4-Dichlorophenoxyacetic acid (2,4-D) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1275	36.16	0.26 (0.22 - 0.30)	<LOD	0.24 (0.21 - 0.28)	0.46 (0.37 - 0.54)	1.2 (0.98 - 1.5)
Males, 6–11	1	525	56.57	—	<LOD	<LOD	0.32 (0.22 - 0.43)	1.0 (0.73 - 1.3)
Males, 6–11	2	260	36.54	0.25 (0.21 - 0.29)	<LOD	0.26 (0.20 - 0.33)	0.44 (0.35 - 0.53)	1.2[E] (0.74 - 1.7)
Males, 12–19	1	504	54.76	—	<LOD	<LOD	0.27 (<LOD - 0.36)	0.70 (0.48 - 0.92)
Males, 12–19	2	255	40.39	—	<LOD	0.24 (<LOD - 0.29)	0.40 (0.27 - 0.53)	0.96 (0.71 - 1.2)
Males, 20–39	1	513	57.70	—	<LOD	<LOD	0.28 (0.20 - 0.36)	0.90 (0.69 - 1.1)
Males, 20–39	2	167	33.53	0.24 (0.20 - 0.29)	<LOD	0.24 (0.21 - 0.28)	0.38 (0.27 - 0.50)	x
Males, 40–59	1	578	57.61	—	<LOD	<LOD	0.33 (0.26 - 0.40)	1.2[E] (0.70 - 1.6)
Males, 40–59	2	192	33.33	0.29 (0.21 - 0.39)	<LOD	0.26[E] (<LOD - 0.36)	0.59[E] (0.31 - 0.88)	x
Males, 60–79	1	541	49.35	—	<LOD	F	0.41 (0.32 - 0.49)	1.3[E] (0.70 - 2.0)
Males, 60–79	2	142	42.25	—	<LOD	0.21[E] (<LOD - 0.30)	0.54[E] (0.26 - 0.82)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1276	47.81	—	<LOD	<LOD	0.35 (0.29 - 0.40)	0.80 (0.57 - 1.0)
Females, 6–11	1	505	58.42	—	<LOD	<LOD	0.31[E] (<LOD - 0.44)	0.89[E] (0.52 - 1.3)
Females, 6–11	2	252	48.41	—	<LOD	0.26 (0.20 - 0.31)	0.48 (0.35 - 0.60)	1.2[E] (0.75 - 1.7)
Females, 12–19	1	477	57.65	—	<LOD	<LOD	0.37[E] (0.20 - 0.54)	0.79 (0.70 - 0.87)
Females, 12–19	2	256	42.97	—	<LOD	0.21 (<LOD - 0.26)	0.39 (0.27 - 0.51)	1.2[E] (0.63 - 1.8)
Females, 20–39	1	653	64.78	—	<LOD	<LOD	0.24 (<LOD - 0.31)	0.57 (0.43 - 0.70)
Females, 20–39	2	190	57.37	—	<LOD	<LOD	0.32 (0.23 - 0.41)	x
Females, 40–59	1	644	62.73	—	<LOD	<LOD	0.22[E] (<LOD - 0.32)	0.72[E] (0.46 - 0.99)
Females, 40–59	2	165	55.76	—	<LOD	<LOD	0.35 (0.25 - 0.46)	x
Females, 60–79	1	540	58.89	—	<LOD	<LOD	0.31[E] (<LOD - 0.43)	0.99 (0.82 - 1.2)
Females, 60–79	2	149	46.98	—	<LOD	<LOD	0.35[E] (0.20 - 0.50)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.3.4

2,4-Dichlorophenoxyacetic acid (2,4-D) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5466	58.25	—	<LOD	<LOD	0.39 (0.36 - 0.42)	1.0 (0.93 - 1.2)
Total, 6–79	2	2019	43.64	—	<LOD	0.21 (<LOD - 0.23)	0.38 (0.34 - 0.42)	1.0 (0.82 - 1.2)
Males, Total 6–79	1	2652	55.39	—	<LOD	<LOD	0.34 (0.29 - 0.38)	0.95 (0.78 - 1.1)
Males, Total 6–79	2	1013	37.31	0.21 (0.19 - 0.24)	<LOD	0.20 (0.15 - 0.24)	0.38 (0.33 - 0.42)	1.2 (0.85 - 1.5)
Females, Total 6–79	1	2814	60.95	—	<LOD	<LOD	0.45 (<LOD - 0.49)	1.1 (1.0 - 1.2)
Females, Total 6–79	2	1006	50.00	—	<LOD	<LOD	0.40 (0.33 - 0.47)	0.88 (0.65 - 1.1)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.3.5

2,4-Dichlorophenoxyacetic acid (2,4-D) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2541	42.15	—	<LOD	0.21 (<LOD - 0.24)	0.40 (0.36 - 0.44)	1.1 (0.87 - 1.2)
3–5[b]	1							
3–5	2	522	36.40	0.45 (0.39 - 0.52)	<LOD	0.40 (0.30 - 0.51)	0.82 (0.68 - 0.96)	2.2 (1.5 - 2.9)
6–11	1	1027	57.64	—	<LOD	<LOD	0.51 (0.44 - 0.58)	1.5 (1.2 - 1.8)
6–11	2	510	42.55	—	<LOD	0.28 (0.24 - 0.31)	0.51 (0.42 - 0.60)	1.2 (0.79 - 1.6)
12–19	1	979	56.28	—	<LOD	<LOD	0.29 (<LOD - 0.34)	0.67 (0.58 - 0.76)
12–19	2	509	41.85	—	<LOD	0.16 (<LOD - 0.20)	0.30 (0.21 - 0.40)	0.68[E] (0.43 - 0.93)
20–39	1	1162	61.88	—	<LOD	<LOD	0.33 (<LOD - 0.36)	0.91 (0.65 - 1.2)
20–39	2	355	46.48	—	<LOD	0.16 (<LOD - 0.19)	0.32 (0.24 - 0.40)	0.74 (0.51 - 0.96)
40–59	1	1217	60.56	—	<LOD	<LOD	0.41 (0.35 - 0.47)	1.1 (0.87 - 1.3)
40–59	2	355	43.94	—	<LOD	0.25 (<LOD - 0.32)	0.40 (0.33 - 0.48)	0.88[E] (0.54 - 1.2)
60–79	1	1081	54.12	—	<LOD	<LOD	0.52 (0.45 - 0.59)	1.4 (1.1 - 1.7)
60–79	2	290	44.83	—	<LOD	<LOD	0.49 (0.38 - 0.60)	1.7[E] (1.1 - 2.3)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 14.3.6

2,4-Dichlorophenoxyacetic acid (2,4-D) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1271	36.27	0.22 (0.20 - 0.24)	<LOD	0.20 (0.16 - 0.24)	0.38 (0.35 - 0.42)	1.2 (0.94 - 1.4)
Males, 6–11	1	523	56.79	—	<LOD	<LOD	0.51 (0.39 - 0.63)	1.5 (1.1 - 1.9)
Males, 6–11	2	259	36.68	0.28 (0.22 - 0.36)	<LOD	0.28 (0.23 - 0.33)	0.55 (0.42 - 0.68)	1.2 (0.82 - 1.5)
Males, 12–19	1	503	54.87	—	<LOD	<LOD	0.27 (<LOD - 0.32)	0.57 (0.50 - 0.63)
Males, 12–19	2	254	40.55	—	<LOD	0.16 (<LOD - 0.20)	0.30 (0.20 - 0.41)	0.63 (0.43 - 0.82)
Males, 20–39	1	511	57.93	—	<LOD	<LOD	0.30 (0.24 - 0.36)	0.78 (0.57 - 0.99)
Males, 20–39	2	166	33.73	0.18 (0.14 - 0.22)	<LOD	0.15 (0.12 - 0.19)	0.27[E] (0.14 - 0.39)	x
Males, 40–59	1	574	58.01	—	<LOD	<LOD	0.33 (0.28 - 0.38)	0.99[E] (0.56 - 1.4)
Males, 40–59	2	192	33.33	0.24 (0.19 - 0.31)	<LOD	0.25 (<LOD - 0.34)	0.39 (0.30 - 0.49)	x
Males, 60–79	1	541	49.35	—	<LOD	<LOD (<LOD - 0.26)	0.40 (0.28 - 0.51)	1.2[E] (0.71 - 1.7)
Males, 60–79	2	142	42.25	—	<LOD	0.20[E] (<LOD - 0.31)	0.44 (0.31 - 0.58)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1270	48.03	—	<LOD	<LOD	0.42 (0.35 - 0.49)	0.91 (0.67 - 1.2)
Females, 6–11	1	504	58.53	—	<LOD	<LOD	0.51 (<LOD - 0.61)	1.5[E] (0.88 - 2.1)
Females, 6–11	2	251	48.61	—	<LOD	0.28 (0.24 - 0.31)	0.48 (0.39 - 0.57)	1.5[E] (0.80 - 2.2)
Females, 12–19	1	476	57.77	—	<LOD	<LOD	0.31 (0.26 - 0.36)	0.71 (0.58 - 0.84)
Females, 12–19	2	255	43.14	—	<LOD	0.17 (<LOD - 0.20)	0.31[E] (0.20 - 0.43)	0.88[E] (0.46 - 1.3)
Females, 20–39	1	651	64.98	—	<LOD	<LOD	0.38 (<LOD - 0.43)	0.98 (0.71 - 1.3)
Females, 20–39	2	189	57.67	—	<LOD	<LOD	0.36[E] (0.23 - 0.49)	x
Females, 40–59	1	643	62.83	—	<LOD	<LOD	0.47 (<LOD - 0.52)	1.2 (0.98 - 1.3)
Females, 40–59	2	163	56.44	—	<LOD	<LOD	0.42 (0.31 - 0.53)	x
Females, 60–79	1	540	58.89	—	<LOD	<LOD	0.61 (<LOD - 0.72)	1.6 (1.3 - 1.9)
Females, 60–79	2	148	47.30	—	<LOD	<LOD	0.51 (0.38 - 0.64)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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14.4 ORGANOPHOSPHATE METABOLITES

Organophosphates are a group of closely related chemicals that are extensively used in Canada as pesticides in agriculture, in the home and garden, and in veterinary practice (Health Canada, 2012a; Health Canada, 2012b; Health Canada, 2012c). This class of pesticides gained popularity in use because organochlorine pesticides were banned in the 1970s. Organophosphate pesticides are less persistent in the environment and less susceptible to pest resistance than the organochlorine pesticides (Wessels et al., 2003). Eighteen organophosphate pesticides were registered for use in Canada during the Canadian Health Measures Survey (CHMS) sampling period (2009–2011) and are listed below in Table 14.4.1 (Health Canada, 2012a).

Organophosphate pesticides have been linked to naturally occurring compounds produced by algae and bacteria; however, their presence in the environment is almost exclusively due to their human use as pesticides (Neumann & Peter, 1987). Despite their rapid degradation in the environment, small amounts can be detected in food and drinking water (Hao et al., 2010; Health Canada, 2003; Health Canada, 2004).

Major uses of organophosphates include as an insecticide on food and feed crops, livestock, and ornamental plants; for insect control in food storage areas, greenhouses, forestry structures, and seed treatment; for control of pet parasites; and for mosquito control (Health Canada, 2012a; Health Canada, 2012b). Although the majority of organophosphates are used as insecticides, bensulide is used as a selective herbicide for the control of weeds in turf and cucumbers (Health Canada, 2012b). In addition to the pesticide uses, dichlorvos and trichlorfon have veterinary drug uses for the control of parasites in livestock (Health Canada, 2012c).

The primary route of exposure for the general public is through ingestion of food previously treated with organophosphate pesticides and drinking water contaminated with agricultural runoff (ATSDR, 1997a; ATSDR, 1997b; ATSDR, 2003). Other routes of exposure include dermal contact and inhalation during the use of products containing organophosphates or during activity in areas previously treated with organophosphates.

After entry into the body, organophosphate pesticides are rapidly metabolized and excreted in urine (Barr & Needham, 2002). Hydrolysis of the parent compound yields various dialkyl phosphate metabolites. Each metabolite is associated with several organophosphate pesticides, and many organophosphates can form more than one of these metabolites (Table 14.4.1). These metabolites also occur in the environment following degradation of the parent compound. Dialkyl phosphate metabolites are not considered toxic, but are considered to be biomarkers of exposure to the parent pesticides and their metabolites in the environment (CDC, 2005; EPA, 1999). In addition to the dialkyl phosphate metabolites, organophosphate parent compounds and other breakdown products can be measured in blood and urine; detection generally reflects exposures over the previous few days (CDC, 2005; EPA, 1999). Some organophosphate pesticides, namely acephate and methamidophos, do not breakdown into dialkyl phosphate metabolites (Barr & Needham, 2002; Wessels et al., 2003).

The following table outlines the dialkyl phosphate metabolites that were measured in urine collected from CHMS participants, and their corresponding organophosphate pesticide parent compounds. There are six dialkyl phosphate metabolites: dimethylphosphate (DMP), dimethylthiophosphate (DMTP), dimethyldithiophosphate (DMDTP), diethylphosphate (DEP), diethylthiophosphate (DETP), and diethyldithiophosphate (DEDTP).

Table 14.4.1

Dialkyl phosphate metabolites measured in the Canadian Health Measures Survey cycle 2 and their parent organophosphate pesticides registered for use in Canada during the cycle 2 sampling period (2009–2011)

Organophosphate pesticide	Dialkyl phosphate metabolite (CASRN)					
	DMP (813-79-5)	DMTP (1112-38-5)	DMDTP (765-80-9)	DEP (598-02-7)	DETP (2465-65-8)	DEDTP (298-06-6)
Acephate	—	—	—	—	—	—
Azinphos-methyl	■	■	■	—	—	—
Bensulide	—	—	—	—	—	—
Chlorpyrifos	—	—	—	■	■	—
Coumaphos	—	—	—	■	■	—
Diazinon	—	—	—	■	■	—
Dichlorvos	■	—	—	—	—	—
Dimethoate	■	■	■	—	—	—
Malathion	■	■	■	—	—	—
Methamidophos	—	—	—	—	—	—
Naled	■	—	—	—	—	—
Phorate	—	—	—	■	■	■
Phosalone	—	—	—	■	■	■
Phosmet	■	■	■	—	—	—
Propetemphos	—	—	—	—	—	—
Terbufos	—	—	—	■	■	■
Tetrachlorvinphos	■	—	—	—	—	—
Trichlorfon	■	—	—	—	—	—

(Bravo et al., 2004; CDC, 2005; Wessels et al., 2003)

Organophosphates are cholinesterase-inhibiting pesticides that act on the nervous system of insects and mammals by interrupting the transmission of nerve impulses (EPA, 1999). The result is an overstimulation in the nervous system. Symptoms of acute over-exposure may include headache, dizziness, fatigue, irritation of the eyes or nose, nausea, vomiting, salivation, sweating, and changes in heart rate. Very high exposures can have effects such as paralysis, seizures, loss of consciousness, or even death (ATSDR, 1997a; ATSDR, 1997b; ATSDR, 2003; EPA, 1999). However, typical exposure through the ingestion of organophosphate pesticides in food is generally low. Nevertheless, there is potential for toxic effects resulting from chronic low-dose exposure (Ray & Richards, 2001). Prenatal exposure to organophosphates has been associated with shortened gestation, reduced birth weight, and impaired neurodevelopment in young children (Eskenazi et al., 2007; Bouchard et al., 2011; Rauch et al., 2012). Four of the 18 organophosphate pesticides registered for use in Canada (Table 14.4.1) have been classified by the International Agency for Research on Cancer. Malathion, tetrachlorvinphos, and trichlorfon are not classifiable as to their carcinogenicity to humans (Group 3), whereas dichlorvos is classified as possibly carcinogenic to humans (Group 2B) (IARC, 1987; IARC, 1991).

The sale and use of organophosphate pesticides is regulated in Canada by the Pest Management Regulatory Agency (PMRA) under the *Pest Control Products Act* (Canada, 2006). PMRA evaluates the toxicity of pesticides and potential exposure in order to determine whether a pesticide should be registered for a specific use. In 1999, PMRA commenced a re-evaluation of the 27 organophosphate pesticides that were registered for use at that time in Canada (Health Canada, 1999). As a result of this review, nine of the pesticides were subsequently discontinued, and certain other pesticides, such as azinphos-methyl, have been restricted to specific uses, with a plan to phase them out when alternatives can be found (Health Canada, 2007). However, the remaining organophosphate pesticides were determined not to pose unacceptable risks to human health or the environment, based on their registered uses. As part of the registration process, PMRA establishes maximum residue limits of pesticides in food, including registered organophosphate pesticides (Health Canada, 2011).

Health Canada has established Canadian drinking water quality guidelines that set out the maximum acceptable concentrations of azinphos-methyl, chlorpyrifos, diazinon, dimethoate, malathion, phorate, and terbufos (Health Canada, 1989a; Health Canada, 1989b; Health Canada, 1989c; Health Canada, 1989d; Health Canada, 1990; Health Canada, 1991; Health Canada, 1995). Several organophosphate pesticides have also been analyzed as part of Health Canada's Total Diet Study surveys (Health Canada, 2009). These surveys provide estimate levels of chemicals that Canadians in different age-sex groups are exposed to through the food supply.

The six dialkyl phosphate metabolites were measured in morning urine voids from 89 children aged 3 to 7 years in a bimonitoring study in the province of Quebec in 2003. The geometric mean and 95th percentile concentrations were 20 µg/g creatinine and 97 µg/g creatinine, respectively, for DMP; 18.8 µg/g creatinine and 210.9 µg/g creatinine, respectively, for DMTP; 2.8 µg/g creatinine and 45.9 µg/g creatinine, respectively, for DMDTP; 4.8 µg/g creatinine and 29 µg/g creatinine, respectively, for DEP; 0.7 µg/g creatinine and 8 µg/g creatinine, respectively, for DETP; and 0.4 µg/g creatinine and 0.4 µg/g creatinine, respectively, for DEDTP (Valcke et al., 2006).

The six dialkyl phosphate metabolites (Table 14.4.1) were measured in the urine of all CHMS participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented as both µg/L and µg/g creatinine (Tables 14.4.1.1 to 14.4.6.6). Finding a measurable amount of organophosphate pesticide metabolites in urine is an indicator of exposure to organophosphate pesticides and/or their metabolites and does not necessarily mean that an adverse health effect will occur.

14.4.1 Dimethylphosphate (DMP)

Table 14.4.1.1

Dimethylphosphate (DMP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5467	20.27	3.0 (2.4 - 3.3)	<LOD	3.0 (2.5 - 3.6)	7.3 (6.6 - 7.9)	25 (21 - 28)
Total, 6–79	2	2034	15.19	3.2 (2.8 - 3.7)	<LOD	3.4 (2.9 - 4.0)	7.3 (6.4 - 8.2)	25 (21 - 29)
Males, Total 6–79	1	2653	19.68	3.0 (2.4 - 3.4)	<LOD	3.1 (2.4 - 3.8)	7.3 (6.6 - 8.1)	25 (20 - 30)
Males, Total 6–79	2	1020	15.39	3.2 (2.7 - 3.7)	<LOD	3.3 (2.7 - 4.0)	6.9 (5.5 - 8.4)	26 (21 - 30)
Females, Total 6–79	1	2814	20.82	2.9 (2.2 - 3.3)	<LOD	3.0 (2.4 - 3.6)	7.2 (6.1 - 8.2)	25 (20 - 29)
Females, Total 6–79	2	1014	14.99	3.3 (2.8 - 3.9)	<LOD	3.6 (2.7 - 4.4)	7.4 (6.2 - 8.7)	24 (17 - 31)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.4.1.2

Dimethylphosphate (DMP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2556	13.58	3.3 (2.9 - 3.8)	<LOD	3.5 (3.0 - 4.0)	7.4 (6.6 - 8.2)	26 (22 - 29)
3–5[b]	1							
3–5	2	522	7.28	6.7 (5.6 - 8.1)	1.4 (1.0 - 1.8)	6.8 (4.9 - 8.6)	15 (12 - 17)	F
6–11	1	1028	17.51	3.9 (3.1 - 4.4)	<LOD	4.3 (3.9 - 4.8)	11 (9.3 - 13)	29 (23 - 36)
6–11	2	516	10.27	6.1 (5.1 - 7.2)	1.3[E] (<LOD - 2.0)	5.9 (4.6 - 7.3)	13 (9.5 - 17)	F
12–19	1	980	15.71	3.9 (3.1 - 4.6)	<LOD	4.1 (3.3 - 4.9)	10 (8.7 - 11)	28 (23 - 32)
12–19	2	512	10.74	3.8 (3.2 - 4.5)	<LOD	4.0 (3.2 - 4.8)	8.2 (6.6 - 9.7)	30 (19 - 41)
20–39	1	1162	23.06	2.7 (2.1 - 3.1)	<LOD	2.9 (2.2 - 3.7)	6.2 (5.3 - 7.0)	23[E] (10 - 36)
20–39	2	356	22.19	3.1 (2.4 - 4.0)	<LOD	3.5 (2.6 - 4.5)	6.5 (4.4 - 8.5)	29 (20 - 39)
40–59	1	1221	26.29	2.7 (2.0 - 3.2)	<LOD	2.9[E] (1.4 - 4.4)	6.7 (5.3 - 8.2)	24 (18 - 31)
40–59	2	360	19.44	2.8 (2.2 - 3.7)	<LOD	2.8 (2.1 - 3.5)	6.3 (4.9 - 7.6)	20[E] (12 - 27)
60–79	1	1076	17.19	3.1 (2.5 - 3.4)	<LOD	3.3 (2.7 - 3.9)	7.7 (6.8 - 8.5)	20 (15 - 26)
60–79	2	290	17.93	3.1 (2.5 - 3.8)	<LOD	3.4 (2.7 - 4.2)	7.1 (5.7 - 8.5)	19[E] (9.9 - 28)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.4.1.3

Dimethylphosphate (DMP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1280	13.59	3.3 (2.8 - 3.8)	<LOD	3.4 (2.8 - 4.0)	7.3 (6.0 - 8.6)	26 (21 - 31)
Males, 6–11	1	524	18.13	3.4 (2.7 - 4.4)	<LOD	3.8 (2.6 - 5.0)	11 (9.2 - 13)	31 (22 - 41)
Males, 6–11	2	262	13.36	5.8 (4.3 - 7.9)	F	5.6 (3.7 - 7.5)	14^{E} (7.3 - 20)	F
Males, 12–19	1	503	17.69	3.4 (2.6 - 4.4)	<LOD	3.7 (2.7 - 4.6)	9.9 (8.4 - 11)	25 (23 - 28)
Males, 12–19	2	256	10.16	3.5 (3.0 - 4.0)	<LOD	3.8 (3.0 - 4.6)	7.4 (6.0 - 8.9)	29^{E} (11 - 48)
Males, 20–39	1	511	22.70	2.5 (2.1 - 3.0)	<LOD	2.9^{E} (1.8 - 4.1)	6.3 (5.4 - 7.2)	F
Males, 20–39	2	166	22.29	3.0 (2.2 - 4.2)	<LOD	3.0^{E} (1.8 - 4.1)	F	x
Males, 40–59	1	577	25.13	2.7 (2.0 - 3.6)	<LOD	3.0^{E} (1.7 - 4.3)	7.1 (4.9 - 9.2)	27^{E} (15 - 38)
Males, 40–59	2	194	17.01	2.8^{E} (1.9 - 4.3)	<LOD	2.8^{E} (1.7 - 3.9)	6.5^{E} (3.9 - 9.2)	x
Males, 60–79	1	538	14.31	3.3 (2.5 - 4.3)	<LOD	3.5 (2.6 - 4.3)	8.3 (6.7 - 10)	24 (18 - 31)
Males, 60–79	2	142	18.31	3.1 (2.2 - 4.3)	<LOD	3.7^{E} (2.3 - 5.0)	6.8 (5.3 - 8.2)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1276	13.56	3.4 (2.9 - 4.0)	<LOD	3.6 (2.8 - 4.5)	7.4 (6.3 - 8.6)	24 (17 - 31)
Females, 6–11	1	504	16.87	4.0 (3.0 - 5.2)	<LOD	4.7 (3.6 - 5.9)	11 (7.7 - 14)	28 (21 - 36)
Females, 6–11	2	254	7.09	6.4 (5.3 - 7.6)	1.5^{E} (<LOD - 2.1)	6.5 (4.7 - 8.3)	13 (9.8 - 16)	41^{E} (26 - 56)
Females, 12–19	1	477	13.63	4.2 (3.3 - 5.4)	<LOD	4.3 (3.2 - 5.4)	10 (8.0 - 12)	38^{E} (23 - 53)
Females, 12–19	2	256	11.33	4.3 (3.1 - 5.9)	<LOD	4.6 (3.0 - 6.3)	9.5^{E} (5.9 - 13)	31^{E} (15 - 47)
Females, 20–39	1	651	23.35	2.6 (2.1 - 3.4)	<LOD	3.0 (2.3 - 3.6)	6.2 (4.8 - 7.5)	29^{E} (17 - 41)
Females, 20–39	2	190	22.11	3.2^{E} (2.1 - 4.8)	<LOD	3.9^{E} (2.4 - 5.4)	7.5^{E} (4.6 - 10)	x
Females, 40–59	1	644	27.33	2.3 (1.7 - 3.1)	<LOD	F	6.5 (4.6 - 8.3)	21 (16 - 26)
Females, 40–59	2	166	22.29	2.9 (2.1 - 4.0)	<LOD	2.8^{E} (1.0 - 4.5)	5.7 (4.0 - 7.4)	x
Females, 60–79	1	538	20.07	2.6 (2.2 - 3.1)	<LOD	3.0 (2.3 - 3.6)	6.7 (5.4 - 7.9)	16^{E} (10 - 23)
Females, 60–79	2	148	17.57	3.0 (2.4 - 3.9)	<LOD	3.2 (2.3 - 4.0)	7.4^{E} (4.4 - 10)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.4.1.4

Dimethylphosphate (DMP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5453	20.32	3.4 (2.9 - 4.0)	<LOD	3.5 (3.0 - 4.1)	7.6 (6.5 - 8.7)	24 (20 - 28)
Total, 6–79	2	2025	15.26	3.1 (2.8 - 3.5)	<LOD	3.0 (2.6 - 3.4)	6.8 (6.1 - 7.5)	22 (17 - 27)
Males, Total 6–79	1	2644	19.74	2.9 (2.4 - 3.4)	<LOD	2.9 (2.4 - 3.4)	6.4 (5.5 - 7.3)	19 (15 - 23)
Males, Total 6–79	2	1017	15.44	2.6 (2.3 - 3.0)	<LOD	2.5 (2.1 - 2.8)	5.4 (4.2 - 6.6)	20 (16 - 25)
Females, Total 6–79	1	2809	20.86	4.1 (3.5 - 4.8)	<LOD	4.2 (3.5 - 5.0)	8.9 (7.6 - 10)	27 (23 - 31)
Females, Total 6–79	2	1008	15.08	3.7 (3.1 - 4.5)	<LOD	3.3 (2.7 - 4.0)	8.0 (6.8 - 9.2)	28 (19 - 37)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.4.1.5

Dimethylphosphate (DMP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2546	13.63	3.3 (2.9 - 3.7)	<LOD	3.2 (2.8 - 3.5)	7.0 (6.3 - 7.7)	25 (19 - 31)
3–5[b]	1							
3–5	2	521	7.29	12 (9.8 - 14)	2.6 (1.9 - 3.3)	12 (8.8 - 16)	22 (16 - 28)	100[E] (40 - 170)
6–11	1	1025	17.56	5.7 (5.0 - 6.6)	<LOD	6.3 (5.0 - 7.5)	14 (13 - 16)	40 (36 - 45)
6–11	2	514	10.31	6.9 (6.0 - 8.0)	1.6 (<LOD - 1.9)	7.2 (6.0 - 8.4)	15 (11 - 18)	52[E] (22 - 83)
12–19	1	978	15.75	3.3 (2.8 - 4.0)	<LOD	3.7 (2.9 - 4.4)	7.8 (6.9 - 8.8)	20 (15 - 24)
12–19	2	510	10.78	2.9 (2.5 - 3.4)	<LOD	2.8 (2.3 - 3.3)	6.0 (4.3 - 7.7)	18[E] (9.9 - 27)
20–39	1	1158	23.14	2.9 (2.5 - 3.4)	<LOD	2.9 (2.4 - 3.4)	6.1 (5.1 - 7.0)	22[E] (13 - 30)
20–39	2	354	22.32	2.7 (2.1 - 3.4)	<LOD	2.5 (1.8 - 3.1)	5.5 (3.8 - 7.2)	23 (16 - 31)
40–59	1	1216	26.40	3.2 (2.6 - 4.0)	<LOD	3.4 (2.6 - 4.1)	7.1 (5.8 - 8.4)	24 (15 - 32)
40–59	2	358	19.55	2.9 (2.4 - 3.5)	<LOD	2.8 (2.3 - 3.2)	5.4[E] (3.3 - 7.5)	17[E] (7.7 - 26)
60–79	1	1076	17.19	4.2 (3.5 - 5.0)	<LOD	4.3 (3.6 - 5.0)	9.4 (8.2 - 11)	23 (18 - 27)
60–79	2	289	17.99	3.6 (2.9 - 4.4)	<LOD	3.8 (2.8 - 4.7)	7.6 (6.2 - 9.0)	19 (14 - 24)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 14.4.1.6

Dimethylphosphate (DMP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1276	13.64	2.8 (2.5 - 3.1)	<LOD	2.5 (2.2 - 2.9)	6.0 (4.9 - 7.0)	21 (17 - 25)
Males, 6–11	1	522	18.20	5.3 (4.4 - 6.3)	<LOD	5.6 (3.7 - 7.6)	13 (10 - 16)	40 (33 - 46)
Males, 6–11	2	261	13.41	6.6 (5.1 - 8.6)	<LOD (<LOD - 2.0)	6.9 (5.0 - 8.7)	16[E] (9.1 - 24)	62[E] (<LOD - 99)
Males, 12–19	1	502	17.73	2.9 (2.3 - 3.6)	<LOD	3.4 (2.5 - 4.3)	7.3 (6.0 - 8.6)	16 (12 - 20)
Males, 12–19	2	255	10.20	2.5 (2.1 - 2.8)	<LOD	2.4 (2.0 - 2.8)	5.1 (3.6 - 6.7)	16[E] (9.2 - 23)
Males, 20–39	1	509	22.79	2.3 (2.0 - 2.8)	<LOD	2.3 (1.9 - 2.6)	4.7 (3.9 - 5.5)	14[E] (<LOD - 22)
Males, 20–39	2	165	22.42	2.2 (1.7 - 2.8)	<LOD	2.0 (1.4 - 2.7)	4.8[E] (<LOD - 6.6)	x
Males, 40–59	1	573	25.31	2.7 (2.0 - 3.5)	<LOD	2.9 (1.9 - 3.9)	5.8 (4.5 - 7.1)	19 (13 - 24)
Males, 40–59	2	194	17.01	2.4 (1.9 - 3.2)	<LOD	2.4 (1.8 - 3.0)	4.1[E] (2.0 - 6.2)	x
Males, 60–79	1	538	14.31	3.6 (2.9 - 4.4)	<LOD	3.7 (2.7 - 4.7)	8.2 (6.6 - 9.8)	20 (14 - 27)
Males, 60–79	2	142	18.31	2.9 (2.2 - 3.8)	<LOD	3.5[E] (2.0 - 5.0)	6.4 (5.3 - 7.5)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1270	13.62	3.8 (3.2 - 4.6)	<LOD	3.4 (2.6 - 4.2)	8.5 (7.3 - 9.7)	28 (20 - 37)
Females, 6–11	1	503	16.90	6.3 (5.2 - 7.6)	<LOD	7.2 (5.1 - 9.3)	15 (13 - 16)	42 (33 - 50)
Females, 6–11	2	253	7.11	7.3 (6.2 - 8.6)	1.7[E] (<LOD - 2.5)	7.4 (5.4 - 9.4)	14 (11 - 17)	F
Females, 12–19	1	476	13.66	3.9 (3.2 - 4.7)	<LOD	4.0 (2.8 - 5.1)	8.6 (7.2 - 9.9)	24 (17 - 31)
Females, 12–19	2	255	11.37	3.5 (2.7 - 4.6)	<LOD	3.3 (2.4 - 4.3)	7.5 (4.8 - 10)	24[E] (9.7 - 39)
Females, 20–39	1	649	23.42	3.6 (2.9 - 4.4)	<LOD	3.9 (3.1 - 4.7)	7.5 (6.0 - 9.0)	26[E] (15 - 36)
Females, 20–39	2	189	22.22	3.2[E] (2.0 - 5.1)	<LOD	3.2[E] (1.9 - 4.5)	6.7[E] (3.3 - 10)	x
Females, 40–59	1	643	27.37	3.9 (3.2 - 4.8)	<LOD	4.0 (<LOD - 5.1)	8.4 (6.3 - 10)	28[E] (18 - 39)
Females, 40–59	2	164	22.56	3.5 (2.7 - 4.4)	<LOD	3.2 (2.3 - 4.1)	7.2[E] (4.3 - 10)	x
Females, 60–79	1	538	20.07	4.8 (4.0 - 5.8)	<LOD	4.8 (3.9 - 5.7)	10 (9.0 - 12)	24 (19 - 30)
Females, 60–79	2	147	17.69	4.3 (3.3 - 5.5)	<LOD	4.4[E] (1.7 - 7.0)	8.6 (5.8 - 11)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.4.2 Dimethylthiophosphate (DMTP)

Table 14.4.2.1

Dimethylthiophosphate (DMTP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5474	30.76	2.0 (1.7 - 2.4)	<LOD	2.0[E] (1.1 - 2.8)	6.9 (5.6 - 8.3)	40 (37 - 43)
Total, 6–79	2	2035	18.03	2.6 (2.2 - 3.1)	<LOD	2.8 (2.1 - 3.4)	7.4[E] (4.6 - 10)	37 (27 - 46)
Males, Total 6–79	1	2659	30.24	2.1 (1.8 - 2.4)	<LOD	2.0 (1.5 - 2.6)	6.6 (5.2 - 7.9)	40 (36 - 44)
Males, Total 6–79	2	1021	18.32	2.4 (2.0 - 2.9)	<LOD	2.3 (1.7 - 2.8)	6.4 (4.3 - 8.4)	36[E] (17 - 56)
Females, Total 6–79	1	2815	31.26	2.0 (1.5 - 2.6)	<LOD	1.8[E] (0.63 - 3.0)	7.2 (5.4 - 9.0)	39 (30 - 49)
Females, Total 6–79	2	1014	17.75	2.8 (2.3 - 3.6)	<LOD	3.2 (2.3 - 4.1)	9.4[E] (5.7 - 13)	37 (28 - 45)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.2.2

Dimethylthiophosphate (DMTP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2559	15.87	2.7 (2.3 - 3.2)	<LOD	2.8 (2.2 - 3.5)	8.1 (5.4 - 11)	37 (27 - 47)
3–5[b]	1							
3–5	2	524	7.44	6.3 (5.1 - 7.8)	0.72 (<LOD - 0.97)	6.4 (4.5 - 8.3)	18 (13 - 23)	89 (60 - 120)
6–11	1	1029	27.89	2.5 (1.9 - 3.2)	<LOD	2.5[E] (1.4 - 3.5)	10 (7.2 - 13)	54 (45 - 64)
6–11	2	516	11.82	5.0 (4.2 - 6.0)	0.64 (<LOD - 0.80)	5.3 (3.7 - 6.9)	14 (9.8 - 18)	66[E] (31 - 100)
12–19	1	980	27.65	2.3 (1.8 - 2.8)	<LOD	2.1 (1.4 - 2.8)	8.1 (6.0 - 10)	44 (30 - 58)
12–19	2	512	16.21	2.6 (2.1 - 3.3)	<LOD	2.7 (2.0 - 3.3)	7.7 (5.0 - 10)	36[E] (22 - 50)
20–39	1	1163	34.48	1.8 (1.3 - 2.4)	<LOD	1.6[E] (<LOD - 2.6)	5.7[E] (3.6 - 7.7)	36[E] (19 - 53)
20–39	2	356	23.60	2.4 (1.8 - 3.2)	<LOD	2.7 (1.8 - 3.7)	6.2[E] (3.1 - 9.2)	29[E] (17 - 41)
40–59	1	1223	36.22	1.8 (1.5 - 2.2)	<LOD	1.4[E] <LOD - 2.3)	6.2 (4.5 - 7.9)	38 (27 - 49)
40–59	2	360	21.94	2.4 (1.8 - 3.2)	<LOD	2.2[E] (1.2 - 3.1)	F	F
60–79	1	1079	26.14	2.6 (2.2 - 3.2)	<LOD	3.0 (2.1 - 3.8)	9.0 (6.6 - 11)	40 (35 - 45)
60–79	2	291	20.62	2.8 (2.1 - 3.8)	<LOD	3.3[E] (2.1 - 4.6)	8.8[E] (5.5 - 12)	44[E] (20 - 68)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.4.2.3

Dimethylthiophosphate (DMTP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1281	16.00	2.5 (2.1 - 3.0)	<LOD	2.4 (1.8 - 3.0)	6.7 (4.3 - 9.1)	37[E] (17 - 57)
Males, 6–11	1	525	29.33	2.5 (1.8 - 3.5)	<LOD	2.3[E] (0.95 - 3.7)	12[E] (6.0 - 18)	55 (39 - 72)
Males, 6–11	2	262	14.50	4.6 (3.4 - 6.2)	0.62[E] (<LOD - 0.95)	4.3[E] (2.7 - 5.9)	10[E] (4.7 - 16)	F
Males, 12–19	1	503	28.03	2.2 (1.7 - 2.7)	<LOD	2.0[E] (1.1 - 2.9)	8.1 (5.4 - 11)	39 (28 - 49)
Males, 12–19	2	256	15.63	2.4 (1.8 - 3.1)	<LOD	2.3[E] (1.3 - 3.4)	6.2 (4.4 - 8.0)	22 (14 - 30)
Males, 20–39	1	512	34.38	1.8 (1.4 - 2.3)	<LOD	1.6[E] (0.81 - 2.4)	5.1[E] (2.7 - 7.5)	39[E] (15 - 63)
Males, 20–39	2	167	25.75	2.2[E] (1.4 - 3.5)	<LOD	1.8[E] (<LOD - 3.1)	F	x
Males, 40–59	1	578	34.60	1.9 (1.5 - 2.4)	<LOD	1.9[E] (1.1 - 2.7)	6.1 (4.1 - 8.0)	33[E] (19 - 47)
Males, 40–59	2	194	19.07	2.4[E] (1.5 - 3.7)	<LOD	1.9[E] (<LOD - 3.2)	F	x
Males, 60–79	1	541	24.58	2.7 (2.1 - 3.5)	<LOD	3.0[E] (1.8 - 4.1)	9.2[E] (4.8 - 13)	43 (35 - 50)
Males, 60–79	2	142	20.42	2.4[E] (1.5 - 3.9)	<LOD	2.7[E] (1.4 - 4.1)	6.7[E] (3.2 - 10)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1278	15.73	2.9 (2.3 - 3.6)	<LOD	3.2 (2.4 - 4.1)	9.5[E] (6.0 - 13)	37 (29 - 45)
Females, 6–11	1	504	26.39	2.5 (1.9 - 3.4)	<LOD	2.6[E] (1.1 - 4.2)	9.4 (6.9 - 12)	54 (43 - 66)
Females, 6–11	2	254	9.06	5.5 (4.1 - 7.4)	0.66[E] (<LOD - 0.91)	6.0[E] (3.2 - 8.8)	16 (13 - 20)	66[E] (29 - 100)
Females, 12–19	1	477	27.25	2.3 (1.6 - 3.4)	<LOD	2.3[E] (1.0 - 3.6)	8.1 (5.3 - 11)	55[E] (23 - 86)
Females, 12–19	2	256	16.80	2.9 (2.1 - 4.1)	<LOD	2.7[E] (1.6 - 3.8)	9.6[E] (5.5 - 14)	43[E] (26 - 59)
Females, 20–39	1	651	34.56	1.8[E] (1.2 - 2.6)	<LOD	F	6.1 (3.9 - 8.4)	34[E] (10 - 58)
Females, 20–39	2	189	21.69	2.6[E] (1.7 - 4.0)	<LOD	3.3[E] (2.1 - 4.5)	5.9[E] (2.8 - 9.1)	x
Females, 40–59	1	645	37.67	1.7 (1.3 - 2.2)	<LOD	F	6.6[E] (3.8 - 9.3)	44[E] (21 - 66)
Females, 40–59	2	166	25.30	2.5[E] (1.6 - 3.9)	<LOD	2.6[E] (1.3 - 3.9)	F	x
Females, 60–79	1	538	27.70	2.6 (2.0 - 3.2)	<LOD	3.0 (2.1 - 3.9)	8.9 (6.0 - 12)	34 (26 - 43)
Females, 60–79	2	149	20.81	3.2 (2.2 - 4.5)	<LOD	3.6[E] (1.5 - 5.7)	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.4.2.4

Dimethylthiophosphate (DMTP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5460	30.84	2.5 (2.1 - 2.9)	<LOD	2.1 (1.6 - 2.5)	8.0 (6.6 - 9.4)	45 (38 - 52)
Total, 6–79	2	2026	18.11	2.6 (2.2 - 3.0)	<LOD	2.5 (1.9 - 3.0)	7.5 (6.0 - 8.9)	34 (29 - 40)
Males, Total 6–79	1	2650	30.34	2.1 (1.8 - 2.3)	<LOD	1.8 (1.5 - 2.2)	6.2 (4.9 - 7.6)	34 (24 - 43)
Males, Total 6–79	2	1018	18.37	2.0 (1.7 - 2.4)	<LOD	1.9 (1.4 - 2.4)	6.1 (4.7 - 7.5)	24 (16 - 32)
Females, Total 6–79	1	2810	31.32	3.0 (2.4 - 3.7)	<LOD	2.5 (1.8 - 3.2)	9.5 (7.8 - 11)	51 (43 - 60)
Females, Total 6–79	2	1008	17.86	3.2 (2.5 - 4.0)	<LOD	3.1[E] (2.0 - 4.2)	9.4 (7.0 - 12)	35 (27 - 43)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.2.5

Dimethylthiophosphate (DMTP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2549	15.93	2.7 (2.3 - 3.1)	<LOD	2.5 (1.9 - 3.2)	7.8 (6.0 - 9.5)	35 (31 - 38)
3–5[b]	1							
3–5	2	523	7.46	11 (9.1 - 13)	1.5 (<LOD - 1.9)	11 (8.2 - 14)	33 (24 - 41)	110 (89 - 140)
6–11	1	1026	27.97	3.9 (3.2 - 4.8)	<LOD	3.7 (2.7 - 4.7)	14 (10 - 17)	70 (52 - 88)
6–11	2	514	11.87	5.7 (4.7 - 7.0)	0.84 (<LOD - 0.99)	5.9[E] (3.4 - 8.4)	16[E] (10 - 23)	90[E] (29 - 150)
12–19	1	978	27.71	2.0 (1.6 - 2.4)	<LOD	2.0 (1.6 - 2.3)	6.2 (4.6 - 7.9)	30 (23 - 36)
12–19	2	510	16.27	2.0 (1.6 - 2.5)	<LOD	1.7 (1.1 - 2.3)	5.7 (4.6 - 6.7)	25[E] (12 - 38)
20–39	1	1159	34.60	2.0 (1.6 - 2.6)	<LOD	1.8 (<LOD - 2.2)	5.8 (3.9 - 7.6)	34[E] (18 - 51)
20–39	2	354	23.73	2.1 (1.6 - 2.7)	<LOD	2.1 (1.5 - 2.7)	6.5 (4.2 - 8.7)	33[E] (17 - 49)
40–59	1	1218	36.37	2.3 (2.0 - 2.7)	<LOD	1.9 (<LOD - 2.4)	7.5 (5.6 - 9.3)	45 (37 - 54)
40–59	2	358	22.07	2.5 (1.9 - 3.2)	<LOD	2.4[E] (1.4 - 3.5)	7.3[E] (3.7 - 11)	30[E] (18 - 41)
60–79	1	1079	26.14	3.7 (3.1 - 4.4)	<LOD	3.8 (2.7 - 4.9)	13 (10 - 15)	53 (40 - 67)
60–79	2	290	20.69	3.3 (2.4 - 4.4)	<LOD	3.5[E] (2.2 - 4.9)	11[E] (6.0 - 17)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

■ Table 14.4.2.6

Dimethylthiophosphate (DMTP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1277	16.05	2.2 (1.8 - 2.6)	<LOD	2.0 (1.4 - 2.5)	6.6 (5.3 - 7.9)	29^{E} (19 - 40)
Males, 6–11	1	523	29.45	3.8 (2.8 - 5.2)	<LOD	3.3^{E} (1.7 - 5.0)	15^{E} (9.6 - 21)	63^{E} (38 - 89)
Males, 6–11	2	261	14.56	5.2 (3.8 - 7.3)	0.79^{E} (<LOD - 1.1)	4.7^{E} (2.4 - 7.0)	14^{E} (6.9 - 21)	F
Males, 12–19	1	502	28.09	1.9 (1.5 - 2.3)	<LOD	1.8 (1.3 - 2.3)	5.5 (3.5 - 7.4)	28 (21 - 36)
Males, 12–19	2	255	15.69	1.7 (1.3 - 2.2)	<LOD	1.6^{E} (0.96 - 2.2)	5.1 (3.7 - 6.6)	19^{E} (9.1 - 28)
Males, 20–39	1	510	34.51	1.7 (1.4 - 2.1)	<LOD	1.5 (1.2 - 1.8)	4.7^{E} (3.0 - 6.5)	F
Males, 20–39	2	166	25.90	1.6^{E} (1.1 - 2.4)	<LOD	1.6 (<LOD - 1.9)	F	x
Males, 40–59	1	574	34.84	1.9 (1.5 - 2.4)	<LOD	1.7 (1.2 - 2.2)	5.3^{E} (2.4 - 8.2)	23^{E} (14 - 33)
Males, 40–59	2	194	19.07	2.0 (1.4 - 2.9)	<LOD	1.9^{E} (<LOD - 2.9)	5.9^{E} (<LOD - 9.1)	x
Males, 60–79	1	541	24.58	2.9 (2.4 - 3.5)	<LOD	3.1 (2.1 - 4.0)	10^{E} (5.5 - 15)	41 (26 - 56)
Males, 60–79	2	142	20.42	2.3 (1.6 - 3.3)	<LOD	2.5^{E} (1.3 - 3.7)	6.7^{E} (3.2 - 10)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1272	15.80	3.3 (2.6 - 4.2)	<LOD	3.4 (2.3 - 4.5)	9.5 (7.1 - 12)	38 (25 - 50)
Females, 6–11	1	503	26.44	4.0 (3.2 - 5.1)	<LOD	4.1 (2.7 - 5.5)	13 (9.3 - 17)	80 (53 - 110)
Females, 6–11	2	253	9.09	6.4 (4.8 - 8.4)	0.90 (<LOD - 1.2)	6.7^{E} (3.3 - 10)	18 (12 - 25)	F
Females, 12–19	1	476	27.31	2.2 (1.6 - 2.8)	<LOD	2.0 (1.7 - 2.4)	7.2 (5.3 - 9.1)	F
Females, 12–19	2	255	16.86	2.4 (1.8 - 3.3)	<LOD	2.1^{E} (1.2 - 3.0)	6.2 (4.0 - 8.3)	38^{E} (13 - 62)
Females, 20–39	1	649	34.67	2.5 (1.8 - 3.4)	<LOD	2.0 (<LOD - 2.7)	7.0^{E} (4.0 - 10)	F
Females, 20–39	2	188	21.81	2.6^{E} (1.7 - 4.0)	<LOD	2.7^{E} (1.2 - 4.3)	6.8 (4.6 - 9.0)	x
Females, 40–59	1	644	37.73	2.8 (2.3 - 3.5)	<LOD	2.2^{E} (<LOD - 3.0)	9.2 (7.2 - 11)	50^{E} (19 - 81)
Females, 40–59	2	164	25.61	3.0 (2.1 - 4.3)	<LOD	2.7^{E} (0.90 - 4.5)	10^{E} (3.8 - 16)	x
Females, 60–79	1	538	27.70	4.7 (3.8 - 5.9)	<LOD	4.8^{E} (2.6 - 6.9)	14 (9.8 - 18)	54 (43 - 66)
Females, 60–79	2	148	20.95	4.5^{E} (3.0 - 6.7)	<LOD	6.1^{E} (2.9 - 9.3)	18^{E} (11 - 24)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.4.3 Dimethyldithiophosphate (DMDTP)

Table 14.4.3.1

Dimethyldithiophosphate (DMDTP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5475	61.95	—	<LOD	<LOD	0.63 (0.42 - 0.85)	5.9 (5.0 - 6.8)
Total, 6–79	2	2014	51.64	—	<LOD	<LOD	0.85 (0.66 - 1.0)	6.3 (4.8 - 7.8)
Males, Total 6–79	1	2659	62.24	—	<LOD	<LOD	0.59 (0.39 - 0.79)	5.5 (4.4 - 6.7)
Males, Total 6–79	2	1011	54.60	—	<LOD	<LOD	0.70 (0.47 - 0.93)	5.4[E] (3.4 - 7.4)
Females, Total 6–79	1	2816	61.68	—	<LOD	<LOD	0.67[E] (0.40 - 0.95)	6.6 (4.8 - 8.4)
Females, Total 6–79	2	1003	48.65	—	<LOD	0.33 (<LOD - 0.42)	0.93[E] (0.55 - 1.3)	7.6 (5.0 - 10)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.3.2

Dimethyldithiophosphate (DMDTP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2537	49.11	—	<LOD	<LOD	0.87 (0.68 - 1.1)	6.5 (5.2 - 7.8)
3–5[b]	1							
3–5	2	523	39.39	0.85 (0.68 - 1.1)	<LOD	0.57[E] (0.32 - 0.83)	2.3[E] (1.1 - 3.4)	18[E] (9.6 - 26)
6–11	1	1029	57.92	—	<LOD	<LOD	0.88 (0.61 - 1.2)	7.2 (4.8 - 9.5)
6–11	2	512	45.12	—	<LOD	0.49[E] (<LOD - 0.75)	1.3 (0.88 - 1.7)	9.3[E] (5.6 - 13)
12–19	1	980	62.04	—	<LOD	<LOD	0.56[E] (0.30 - 0.82)	7.0 (4.9 - 9.1)
12–19	2	512	50.59	—	<LOD	<LOD	0.68 (0.48 - 0.88)	F
20–39	1	1163	66.98	—	<LOD	<LOD	0.52[E] (0.29 - 0.74)	4.6[E] (2.4 - 6.7)
20–39	2	357	60.22	—	<LOD	<LOD	0.59 (0.41 - 0.77)	4.4[E] (2.3 - 6.4)
40–59	1	1223	66.56	—	<LOD	<LOD	0.56[E] (0.33 - 0.79)	5.8 (4.3 - 7.4)
40–59	2	353	58.64	—	<LOD	<LOD	0.86[E] (0.32 - 1.4)	6.1[E] (2.7 - 9.5)
60–79	1	1080	55.09	—	<LOD	<LOD	1.0 (0.67 - 1.3)	7.5 (5.0 - 9.9)
60–79	2	280	45.71	—	<LOD	F	1.1[E] (0.34 - 1.9)	9.5[E] (3.7 - 15)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.4.3.3

Dimethyldithiophosphate (DMDTP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1271	51.30	—	<LOD	<LOD	0.73 (0.49 - 0.98)	5.7 (3.8 - 7.6)
Males, 6–11	1	525	59.62	—	<LOD	<LOD	0.82[E] (0.38 - 1.3)	8.5[E] (4.0 - 13)
Males, 6–11	2	262	50.38	—	<LOD	F	1.2 (0.82 - 1.7)	F
Males, 12–19	1	503	62.03	—	<LOD	<LOD	0.53[E] (0.27 - 0.79)	F
Males, 12–19	2	256	53.52	—	<LOD	<LOD	0.54[E] (0.30 - 0.78)	F
Males, 20–39	1	512	67.97	—	<LOD	<LOD	0.50[E] (0.26 - 0.74)	4.5[E] (2.0 - 7.0)
Males, 20–39	2	167	67.07	—	<LOD	<LOD	F	x
Males, 40–59	1	578	66.26	—	<LOD	<LOD	0.60[E] (0.36 - 0.84)	5.7 (4.4 - 6.9)
Males, 40–59	2	189	57.14	—	<LOD	<LOD	F	x
Males, 60–79	1	541	55.27	—	<LOD	<LOD	0.99 (0.71 - 1.3)	7.4[E] (2.6 - 12)
Males, 60–79	2	137	45.99	—	<LOD	F	0.92[E] (0.34 - 1.5)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1266	46.92	—	<LOD	0.33 (<LOD - 0.42)	0.96[E] (0.58 - 1.3)	7.8 (5.5 - 10)
Females, 6–11	1	504	56.15	—	<LOD	<LOD	0.96[E] (0.57 - 1.4)	5.7[E] (3.2 - 8.2)
Females, 6–11	2	250	39.60	0.68 (0.50 - 0.92)	<LOD	0.50[E] (<LOD - 0.75)	1.4[E] (0.65 - 2.1)	8.8[E] (4.8 - 13)
Females 12–19	1	477	62.05	—	<LOD	<LOD	0.66[E] (0.21 - 1.1)	7.9[E] (3.2 - 13)
Females, 12–19	2	256	47.66	—	<LOD	<LOD[E] (<LOD - 0.34)	0.86[E] (0.53 - 1.2)	7.2[E] (2.3 - 12)
Females, 20–39	1	651	66.21	—	<LOD	<LOD	0.57[E] (0.33 - 0.80)	F
Females, 20–39	2	190	54.21	—	<LOD	0.30 (<LOD - 0.40)	0.59[E] (0.37 - 0.81)	x
Females, 40–59	1	645	66.82	—	<LOD	<LOD	0.51[E] (0.15 - 0.87)	F
Females, 40–59	2	164	60.37	—	<LOD	F	F	x
Females, 60–79	1	539	54.92	—	<LOD	<LOD	1.0[E] (0.41 - 1.7)	7.3[E] (3.9 - 11)
Females, 60–79	2	143	45.45	—	<LOD	0.54[E] (<LOD - 0.81)	2.0[E] (0.79 - 3.2)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.4.3.4

Dimethyldithiophosphate (DMDTP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5461	62.11	—	<LOD	<LOD	0.62[E] (0.38 - 0.87)	7.3 (5.6 - 9.1)
Total, 6–79	2	2005	51.87	—	<LOD	<LOD	0.95 (0.76 - 1.1)	6.8 (4.7 - 8.9)
Males, Total 6–79	1	2650	62.45	—	<LOD	<LOD	0.47 (0.31 - 0.64)	5.5[E] (2.8 - 8.3)
Males, Total 6–79	2	1008	54.76	—	<LOD	<LOD	0.58[E] (0.37 - 0.79)	3.8[E] (2.4 - 5.2)
Females, Total 6–79	1	2811	61.79	—	<LOD	<LOD	0.78[E] (0.42 - 1.1)	8.7 (6.4 - 11)
Females, Total 6–79	2	997	48.95	—	<LOD	0.40 (<LOD - 0.54)	1.2 (0.82 - 1.5)	9.1 (7.0 - 11)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.3.5

Dimethyldithiophosphate (DMDTP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2527	49.31	—	<LOD	<LOD	0.96 (0.80 - 1.1)	7.3 (5.3 - 9.3)
3–5[b]	1							
3–5	2	522	39.46	1.3 (1.0 - 1.7)	<LOD	0.96 (0.70 - 1.2)	3.7[E] (1.9 - 5.5)	27[E] (16 - 38)
6–11	1	1026	58.09	—	<LOD	<LOD	1.1[E] (0.63 - 1.5)	11 (8.5 - 13)
6–11	2	510	45.29	—	<LOD	0.52[E] (<LOD - 0.72)	1.5[E] (0.93 - 2.1)	9.7[E] (5.2 - 14)
12–19	1	978	62.17	—	<LOD	<LOD	0.43[E] (0.19 - 0.67)	5.3[E] (3.2 - 7.4)
12–19	2	510	50.78	—	<LOD	<LOD	0.49 (0.33 - 0.65)	F
20–39	1	1159	67.21	—	<LOD	<LOD	0.46[E] (0.27 - 0.64)	4.8[E] (2.6 - 6.9)
20–39	2	355	60.56	—	<LOD	<LOD	0.55[E] (0.17 - 0.93)	4.2[E] (1.3 - 7.0)
40–59	1	1218	66.83	—	<LOD	<LOD	0.54[E] (0.29 - 0.79)	8.7 (6.1 - 11)
40–59	2	351	58.97	—	<LOD	<LOD	0.95[E] (0.51 - 1.4)	6.7[E] (3.1 - 10)
60–79	1	1080	55.09	—	<LOD	<LOD	1.4 (0.94 - 1.8)	9.3[E] (3.8 - 15)
60–79	2	279	45.88	—	<LOD	0.51[E] (<LOD - 0.71)	1.8 (1.2 - 2.4)	10[E] (6.0 - 15)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.4.3.6

Dimethyldithiophosphate (DMDTP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011)

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1267	51.46	—	<LOD	<LOD	0.64[E] (0.40 - 0.88)	4.5 (3.0 - 5.9)
Males, 6–11	1	523	59.85	—	<LOD	<LOD	F	12[E] (7.1 - 16)
Males, 6–11	2	261	50.57	—	<LOD	0.52[E] (<LOD - 0.89)	1.5[E] (0.78 - 2.2)	F
Males, 12–19	1	502	62.15	—	<LOD	<LOD	0.34[E] (0.14 - 0.53)	F
Males, 12–19	2	255	53.73	—	<LOD	<LOD	0.33[E] (0.19 - 0.48)	F
Males, 20–39	1	510	68.24	—	<LOD	<LOD	0.42[E] (0.24 - 0.60)	F
Males, 20–39	2	166	67.47	—	<LOD	<LOD	F	x
Males, 40–59	1	574	66.72	—	<LOD	<LOD	0.46[E] (0.27 - 0.66)	5.1[E] (1.4 - 8.8)
Males, 40–59	2	189	57.14	—	<LOD	<LOD	0.57[E] (<LOD - 0.80)	x
Males, 60–79	1	541	55.27	—	<LOD	<LOD	0.95 (0.64 - 1.3)	8.1[E] (3.4 - 13)
Males, 60–79	2	137	45.99	—	<LOD	<LOD (<LOD - 0.45)	0.95[E] (0.40 - 1.5)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1260	47.14	—	<LOD	0.41 (<LOD - 0.55)	1.3 (0.93 - 1.7)	9.4 (7.3 - 11)
Females, 6–11	1	503	56.26	—	<LOD	<LOD	1.2[E] (0.66 - 1.7)	9.9 (7.4 - 12)
Females, 6–11	2	249	39.76	0.71 (0.51 - 0.97)	<LOD	0.52[E] (<LOD - 0.74)	1.5[E] (0.70 - 2.2)	10[E] (5.6 - 15)
Females, 12–19	1	476	62.18	—	<LOD	<LOD	0.63[E] (0.22 - 1.0)	F
Females, 12–19	2	255	47.84	—	<LOD	<LOD (<LOD - 0.40)	0.79[E] (0.42 - 1.2)	4.3[E] (1.5 - 7.1)
Females, 20–39	1	649	66.41	—	<LOD	<LOD	0.57[E] (0.29 - 0.86)	F
Females, 20–39	2	189	54.50	—	<LOD	0.29 (<LOD - 0.38)	0.83[E] (0.50 - 1.2)	x
Females, 40–59	1	644	66.93	—	<LOD	<LOD	0.68[E] (0.31 - 1.0)	11 (<LOD - 14)
Females, 40–59	2	162	61.11	—	<LOD	0.57[E] (<LOD - 0.87)	1.3[E] (<LOD - 2.0)	x
Females, 60–79	1	539	54.92	—	<LOD	<LOD	2.0[E] (0.92 - 3.0)	11[E] (3.2 - 19)
Females, 60–79	2	142	45.77	—	<LOD	0.83[E] (<LOD - 1.3)	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.4.4 Diethylphosphate (DEP)

Table 14.4.4.1

Diethylphosphate (DEP) — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5475	20.40	2.0 (1.7 - 2.4)	<LOD	2.3 (2.0 - 2.6)	4.7 (4.4 - 5.0)	12 (11 - 14)
Total, 6–79	2	2033	14.85	2.7 (2.5 - 3.0)	<LOD	2.7 (2.4 - 3.0)	5.6 (5.0 - 6.3)	18 (16 - 21)
Males, Total 6–79	1	2659	19.03	2.1 (1.8 - 2.5)	<LOD	2.4 (2.0 - 2.7)	4.8 (4.5 - 5.1)	13 (11 - 15)
Males, Total 6–79	2	1019	13.54	2.8 (2.5 - 3.2)	<LOD	2.9 (2.[illegible] 3.4)	5.6 (4.5 - 6.8)	17[E] (9.8 - 25)
Females, Total 6–79	1	2816	21.70	2.0 (1.6 - 2.4)	<LOD	2.2 (1.9 - 2.5)	4.6 (4.2 - 5.0)	12 (9.9 - 14)
Females, Total 6–79	2	1014	16.17	2.7 (2.3 - 3.1)	<LOD	2.6 (2.2 - 2.9)	5.6 (4.7 - 6.6)	19 (15 - 22)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.4.2

Diethylphosphate (DEP) — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%[illegible]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2556	13.58	2.8 (2.6 - 3.1)	<LOD	2.8 (2.5 - 3.1)	5.7 (5.1 - 6.4)	19 (16 - 21)
3–5[b]	1							
3–5	2	523	8.60	4.9 (4.1 - 5.9)	1.2 (<LOD - 1.6)	5.1 (4.1 - 6.1)	9.3 (7.2 - 12)	29[E] (9.9 - 48)
6–11	1	1029	17.88	2.6 (1.9 - 3.5)	<LOD	3.0 (2.3 - 3.6)	6.4 (5.5 - 7.3)	17 (14 - 20)
6–11	2	515	11.26	4.1 (3.7 - 4.7)	1.1 (<LOD - 1.3)	4.0 (3.5 - 4.5)	8.1 (6.6 - 9.7)	23[E] (12 - 33)
12–19	1	980	17.35	2.7 (2.1 - 3.4)	<LOD	3.1 (2.4 - 3.7)	6.2 (5.2 - 7.2)	18 (14 - 22)
12–19	2	512	12.30	3.4 (3.0 - 3.9)	<LOD	3.1 (2.6 - 3.7)	7.4 (5.8 - 8.9)	23[E] (14 - 31)
20–39	1	1163	22.96	1.9 (1.5 - 2.4)	<LOD	2.1 (1.8 - 2.5)	4.1 (3.6 - 4.6)	12 (8.6 - 14)
20–39	2	357	16.81	2.7 (2.3 - 3.2)	<LOD	2.6 (2.2 - 3.0)	5.3 (4.3 - 6.2)	20[E] (7.9 - 32)
40–59	1	1223	25.35	1.8 (1.5 - 2.2)	<LOD	2.1 (1.8 - 2.4)	4.5 (3.8 - 5.1)	11 (8.2 - 13)
40–59	2	360	19.72	2.5 (2.0 - 3.1)	<LOD	2.5 (1.9 - 3.1)	5.0 (3.5 - 6.4)	16[E] (8.6 - 23)
60–79	1	1080	17.22	2.2 (1.9 - 2.5)	<LOD	2.3 (2.0 - 2.7)	4.8 (4.3 - 5.3)	12 (9.8 - 13)
60–79	2	289	17.30	2.6 (2.0 - 3.3)	<LOD	2.6 (1.9 - 3.4)	5.6 (3.9 - 7.4)	16 (12 - 21)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 14.4.4.3

Diethylphosphate (DEP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1279	12.51	2.9 (2.6 - 3.3)	<LOD	2.9 (2.5 - 3.4)	5.7 (4.6 - 6.9)	18[E] (11 - 26)
Males, 6–11	1	525	18.67	2.6 (1.8 - 3.7)	<LOD	2.9 (1.9 - 3.8)	6.5 (5.3 - 7.7)	18 (12 - 24)
Males, 6–11	2	261	10.73	4.0 (3.2 - 4.9)	1.2 (<LOD - 1.5)	3.6 (2.5 - 4.7)	7.5 (5.1 - 9.9)	21[E] (7.1 - 34)
Males, 12–19	1	503	16.30	2.6 (2.1 - 3.4)	<LOD	2.9 (2.1 - 3.7)	6.1 (4.9 - 7.4)	17 (13 - 21)
Males, 12–19	2	256	12.50	3.3 (2.6 - 4.2)	<LOD	3.0 (1.9 - 4.0)	7.0 (4.8 - 9.3)	F
Males, 20–39	1	512	22.66	1.8 (1.4 - 2.4)	<LOD	2.1 (1.7 - 2.6)	4.1 (3.3 - 4.8)	11 (7.8 - 15)
Males, 20–39	2	167	13.77	2.9 (2.1 - 4.2)	<LOD	2.8 (2.1 - 3.5)	5.6 (4.0 - 7.2)	x
Males, 40–59	1	578	21.45	2.0 (1.6 - 2.5)	<LOD	2.3 (1.8 - 2.7)	4.6 (3.8 - 5.5)	12 (7.6 - 16)
Males, 40–59	2	194	18.04	2.3 (1.8 - 3.1)	<LOD	2.6[E] (1.5 - 3.7)	4.7[E] (2.8 - 6.6)	x
Males, 60–79	1	541	15.90	2.4 (2.0 - 3.0)	<LOD	2.6 (1.9 - 3.3)	5.3 (4.3 - 6.3)	13 (9.2 - 16)
Males, 60–79	2	141	14.18	3.0 (2.1 - 4.3)	<LOD	3.1[E] (1.9 - 4.3)	5.9[E] (3.1 - 8.6)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1277	14.64	2.7 (2.3 - 3.1)	<LOD	2.6 (2.2 - 2.9)	5.7 (4.8 - 6.7)	19 (15 - 23)
Females, 6–11	1	504	17.06	2.6 (1.9 - 3.5)	<LOD	3.0 (2.4 - 3.7)	6.3 (5.2 - 7.4)	16 (13 - 20)
Females, 6–11	2	254	11.81	4.3 (3.4 - 5.6)	<LOD	4.4 (3.3 - 5.4)	9.0 (6.8 - 11)	F
Females, 12–19	1	477	18.45	2.7 (2.1 - 3.6)	<LOD	3.2 (2.4 - 3.9)	6.4 (5.1 - 7.7)	21 (15 - 28)
Females, 12–19	2	256	12.11	3.5 (2.8 - 4.4)	1.0[E] (<LOD - 1.5)	3.2 (2.4 - 3.9)	7.5 (5.3 - 9.8)	21[E] (13 - 29)
Females, 20–39	1	651	23.20	2.0 (1.5 - 2.6)	<LOD	2.1 (1.8 - 2.5)	4.2 (3.7 - 4.7)	12[E] (7.6 - 17)
Females, 20–39	2	190	19.47	2.5 (1.9 - 3.3)	<LOD	2.5 (1.7 - 3.3)	5.2 (3.7 - 6.6)	x
Females, 40–59	1	645	28.84	1.7 (1.3 - 2.1)	<LOD	2.0 (1.7 - 2.3)	4.2 (3.3 - 5.0)	10 (8.0 - 12)
Females, 40–59	2	166	21.69	2.6 (1.9 - 3.7)	<LOD	2.5 (1.7 - 3.2)	5.5[E] (3.5 - 7.5)	x
Females, 60–79	1	539	18.55	1.9 (1.7 - 2.2)	<LOD	2.1 (1.9 - 2.3)	4.1 (3.3 - 4.9)	10 (8.3 - 13)
Females, 60–79	2	148	20.27	2.2 (1.6 - 3.0)	<LOD	2.1[E] (1.3 - 2.8)	5.5[E] (2.5 - 8.5)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.4.4.4

Diethylphosphate (DEP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5461	20.45	2.4 (2.0 - 2.8)	<LOD	2.6 (2.3 - 3.0)	5.2 (4.8 - 5.5)	12 (11 - 13)
Total, 6–79	2	2024	14.92	2.6 (2.4 - 2.8)	<LOD	2.5 (2.3 - 2.8)	4.6 (4.2 - 5.0)	14 (12 - 16)
Males, Total 6–79	1	2650	19.09	2.0 (1.7 - 2.4)	<LOD	2.3 (2.0 - 2.6)	4.4 (4.1 - 4.7)	11 (10 - 12)
Males, Total 6–79	2	1016	13.58	2.3 (2.0 - 2.6)	<LOD	2.2 (1.9 - 2.5)	4.2 (3.5 - 4.9)	14 (9.7 - 18)
Females, Total 6–79	1	2811	21.74	2.8 (2.4 - 3.3)	<LOD	3.1 (2.5 - 3.6)	5.8 (5.3 - 6.3)	14 (12 - 16)
Females, Total 6–79	2	1008	16.27	3.0 (2.6 - 3.4)	<LOD	2.8 (2.4 - 3.3)	5.0 (4.0 - 6.0)	14 (10 - 18)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.4.4.5

Diethylphosphate (DEP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2546	13.63	2.7 (2.5 - 3.0)	<LOD	2.6 (2.3 - 2.9)	4.8 (4.4 - 5.2)	15 (12 - 17)
3–5[b]	1							
3–5	2	522	8.62	8.5 (7.3 - 9.9)	2.6 (<LOD - 3.3)	8.6 (7.2 - 10)	15 (10 - 19)	44 (33 - 56)
6–11	1	1026	17.93	3.9 (3.0 - 5.0)	<LOD	4.0 (3.3 - 4.8)	8.4 (7.0 - 9.8)	24 (20 - 29)
6–11	2	513	11.31	4.8 (4.3 - 5.3)	1.6 (<LOD - 1.8)	4.6 (3.9 - 5.2)	8.8 (7.0 - 11)	25^{E} (12 - 38)
12–19	1	978	17.38	2.3 (1.8 - 2.9)	<LOD	2.5 (2.0 - 3.0)	5.1 (4.6 - 5.6)	12 (10 - 13)
12–19	2	510	12.35	2.6 (2.3 - 3.0)	<LOD	2.5 (2.0 - 3.0)	4.7 (3.9 - 5.5)	16^{E} (9.9 - 21)
20–39	1	1159	23.04	2.1 (1.7 - 2.6)	<LOD	2.2 (1.9 - 2.6)	4.3 (3.6 - 4.9)	10 (8.3 - 12)
20–39	2	355	16.90	2.2 (1.9 - 2.7)	<LOD	2.1 (1.5 - 2.7)	3.7 (3.2 - 4.3)	F
40–59	1	1218	25.45	2.3 (1.9 - 2.7)	<LOD	2.5 (2.2 - 2.9)	5.0 (4.5 - 5.5)	11 (10 - 13)
40–59	2	358	19.83	2.5 (2.2 - 2.9)	<LOD	2.4 (2.0 - 2.8)	4.6 (3.7 - 5.5)	11 (7.6 - 15)
60–79	1	1080	17.22	3.0 (2.6 - 3.4)	<LOD	3.4 (3.1 - 3.8)	6.2 (5.5 - 6.9)	13 (11 - 16)
60–79	2	288	17.36	3.0 (2.5 - 3.7)	<LOD	2.9 (2.2 - 3.6)	5.4 (4.0 - 6.7)	14 (10 - 17)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.4.4.6

Diethylphosphate (DEP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1275	12.55	2.4 (2.1 - 2.7)	<LOD	2.2 (1.8 - 2.6)	4.6 (3.9 - 5.3)	14 (9.6 - 19)
Males, 6–11	1	523	18.74	3.8 (2.9 - 5.0)	<LOD	4.1 (3.0 - 5.2)	8.2 (7.0 - 9.4)	25 (17 - 32)
Males, 6–11	2	260	10.77	4.5 (3.7 - 5.5)	1.5 (<LOD - 1.9)	4.6 (3.2 - 6.0)	8.2[E] (5.1 - 11)	22 (17 - 28)
Males, 12–19	1	502	16.33	2.2 (1.8 - 2.7)	<LOD	2.5 (2.0 - 2.9)	5.1 (4.5 - 5.6)	11 (8.4 - 14)
Males, 12–19	2	255	12.55	2.3 (1.9 - 2.9)	<LOD	1.9[E] (1.1 - 2.8)	4.4[E] (2.6 - 6.2)	17[E] (9.6 - 25)
Males, 20–39	1	510	22.75	1.6 (1.3 - 2.1)	<LOD	1.8 (1.4 - 2.1)	3.3 (2.7 - 4.0)	7.6 (6.4 - 8.8)
Males, 20–39	2	166	13.86	2.0 (1.4 - 2.8)	<LOD	1.7[E] (1.0 - 2.4)	3.2 (2.2 - 4.3)	x
Males, 40–59	1	574	21.60	1.9 (1.6 - 2.3)	<LOD	2.2 (1.8 - 2.6)	4.0 (3.3 - 4.7)	11 (9.8 - 12)
Males, 40–59	2	194	18.04	2.0 (1.6 - 2.5)	<LOD	2.0 (1.5 - 2.4)	3.6 (2.6 - 4.7)	x
Males, 60–79	1	541	15.90	2.5 (2.1 - 3.0)	<LOD	3.0 (2.5 - 3.4)	5.2 (4.5 - 6.0)	11 (8.6 - 13)
Males, 60–79	2	141	14.18	2.8 (2.3 - 3.6)	<LOD	2.9 (2.3 - 3.5)	4.9 (3.9 - 5.8)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1271	14.71	3.1 (2.7 - 3.5)	<LOD	2.9 (2.5 - 3.4)	5.4 (4.3 - 6.5)	15 (11 - 19)
Females, 6–11	1	503	17.10	3.9 (3.0 - 5.1)	<LOD	4.0 (3.4 - 4.6)	8.7 (6.4 - 11)	24 (19 - 30)
Females, 6–11	2	253	11.86	5.1 (4.1 - 6.2)	<LOD	4.4 (3.0 - 5.8)	9.1 (6.8 - 11)	28[E] (13 - 44)
Females, 12–19	1	476	18.49	2.4 (1.9 - 3.1)	<LOD	2.6 (1.9 - 3.3)	5.1 (4.3 - 6.0)	12 (11 - 14)
Females, 12–19	2	255	12.16	2.9 (2.3 - 3.6)	1.0 (<LOD - 1.3)	2.9 (2.0 - 3.8)	4.9 (4.1 - 5.7)	13[E] (7.8 - 18)
Females, 20–39	1	649	23.27	2.6 (2.1 - 3.3)	<LOD	2.7 (2.2 - 3.2)	5.3 (4.5 - 6.1)	12 (9.2 - 16)
Females, 20–39	2	189	19.58	2.5 (1.9 - 3.3)	<LOD	2.5 (1.6 - 3.3)	4.0 (3.1 - 4.9)	x
Females, 40–59	1	644	28.88	2.7 (2.2 - 3.2)	<LOD	3.1 (2.4 - 3.8)	5.5 (4.8 - 6.1)	12 (9.5 - 14)
Females, 40–59	2	164	21.95	3.1 (2.6 - 3.8)	<LOD	2.8 (2.3 - 3.3)	5.7 (4.1 - 7.4)	x
Females, 60–79	1	539	18.55	3.5 (3.0 - 4.0)	<LOD	4.0 (3.3 - 4.7)	7.1 (5.9 - 8.2)	17[E] (9.3 - 25)
Females, 60–79	2	147	20.41	3.2 (2.4 - 4.2)	<LOD	2.6[E] (1.5 - 3.7)	6.1[E] (2.6 - 9.5)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.4.5 Diethylthiophosphate (DETP)

Table 14.4.5.1

Diethylthiophosphate (DETP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5474	59.77	—	<LOD	<LOD	0.98 (0.82 - 1.1)	4.0 (3.1 - 4.8)
Total, 6–79	2	1999	25.46	0.65 (0.59 - 0.71)	<LOD	0.59 (0.49 - 0.69)	1.1 (1.0 - 1.3)	5.2^E (3.0 - 7.4)
Males, Total 6–79	1	2658	58.50	—	<LOD	<LOD	0.98 (0.82 - 1.1)	4.0 (2.8 - 5.2)
Males, Total 6–79	2	1006	25.05	0.62 (0.55 - 0.70)	<LOD	0.56 (0.46 - 0.66)	1.1 (0.92 - 1.3)	3.5^E (1.7 - 5.3)
Females, Total 6–79	1	2816	60.97	—	<LOD	<LOD	0.99 (0.81 - 1.2)	3.8 (2.9 - 4.8)
Females, Total 6–79	2	993	25.88	0.68 (0.58 - 0.79)	<LOD	0.61 (0.45 - 0.77)	1.2 (0.96 - 1.4)	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 14.4.5.2

Diethylthiophosphate (DETP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2511	23.26	0.66 (0.60 - 0.72)	<LOD	0.60 (0.51 - 0.70)	1.2 (1.0 - 1.3)	5.3^E (3.2 - 7.4)
3–5[b]	1							
3–5	2	512	14.65	1.0 (0.92 - 1.2)	<LOD	1.0 (0.91 - 1.1)	1.9 (1.5 - 2.4)	6.7^E (3.4 - 10)
6–11	1	1029	54.71	—	<LOD	<LOD	1.1 (0.89 - 1.3)	4.8 (3.9 - 5.7)
6–11	2	508	22.05	0.85 (0.74 - 0.98)	<LOD	0.78 (0.68 - 0.88)	1.5 (1.2 - 1.9)	F
12–19	1	979	54.55	—	<LOD	<LOD	1.1 (0.84 - 1.4)	4.1 (3.1 - 5.1)
12–19	2	504	22.82	0.67 (0.57 - 0.78)	<LOD	0.59 (0.47 - 0.71)	1.3 (1.0 - 1.6)	4.1^E (2.5 - 5.7)
20–39	1	1163	64.14	—	<LOD	<LOD	0.88 (0.69 - 1.1)	2.9 (1.9 - 3.8)
20–39	2	349	29.23	0.57 (0.48 - 0.69)	<LOD	0.47^E (<LOD - 0.64)	1.0 (0.81 - 1.2)	5.4^E (1.6 - 9.1)
40–59	1	1223	65.74	—	<LOD	<LOD	0.98 (0.72 - 1.2)	4.6^E (2.8 - 6.5)
40–59	2	352	28.41	0.66 (0.53 - 0.83)	<LOD	0.65 (0.46 - 0.84)	1.1 (0.84 - 1.5)	F
60–79	1	1080	57.87	—	<LOD	<LOD	1.1 (0.88 - 1.2)	4.1 (3.5 - 4.7)
60–79	2	286	27.97	0.67 (0.55 - 0.83)	<LOD	0.59 (0.41 - 0.76)	1.2 (0.90 - 1.6)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.4.5.3

Diethylthiophosphate (DETP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1261	22.84	0.63 (0.56 - 0.71)	<LOD	0.58 (0.49 - 0.67)	1.1 (0.96 - 1.3)	3.5^{E} (1.6 - 5.5)
Males, 6–11	1	525	53.90	—	<LOD	<LOD	1.2 (0.84 - 1.5)	5.4^{E} (2.5 - 8.2)
Males, 6–11	2	260	22.69	0.80 (0.68 - 0.95)	<LOD	0.81 (0.65 - 0.97)	1.5 (1.1 - 2.0)	4.0 (3.1 - 5.0)
Males, 12–19	1	502	54.38	—	<LOD	<LOD	1.1 (0.82 - 1.3)	4.4^{E} (2.2 - 6.5)
Males, 12–19	2	250	23.20	0.68 (0.56 - 0.82)	<LOD	0.64 (0.45 - 0.83)	1.3 (0.90 - 1.7)	3.5^{E} (2.1 - 4.9)
Males, 20–39	1	512	64.06	—	<LOD	<LOD	0.86 (0.60 - 1.1)	2.8^{E} (1.4 - 4.2)
Males, 20–39	2	164	27.44	0.51 (0.38 - 0.66)	<LOD	0.44^{E} (<LOD - 0.61)	0.79^{E} (0.37 - 1.2)	x
Males, 40–59	1	578	65.92	—	<LOD	<LOD	0.96 (0.71 - 1.2)	4.6^{E} (2.7 - 6.5)
Males, 40–59	2	192	27.60	0.63 (0.46 - 0.87)	<LOD	0.57^{E} (0.32 - 0.81)	1.2^{E} (0.57 - 1.8)	x
Males, 60–79	1	541	53.60	—	<LOD	<LOD	1.2 (0.98 - 1.5)	4.1^{E} (1.9 - 6.4)
Males, 60–79	2	140	26.43	0.73 (0.51 - 1.0)	<LOD	0.67 (0.48 - 0.86)	F	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1250	23.68	0.68 (0.59 - 0.79)	<LOD	0.61 (0.46 - 0.76)	1.2 (0.97 - 1.4)	5.6^{E} (1.6 - 9.5)
Females, 6–11	1	504	55.56	—	<LOD	<LOD	1.1 (0.69 - 1.4)	4.3 (3.2 - 5.3)
Females, 6–11	2	248	21.37	0.91 (0.68 - 1.2)	<LOD	0.77 (0.62 - 0.92)	F	F
Females, 12–19	1	477	54.72	—	<LOD	<LOD	1.2 (0.80 - 1.6)	4.0 (3.2 - 4.7)
Females, 12–19	2	254	22.44	0.66 (0.52 - 0.83)	<LOD	0.55 (0.39 - 0.71)	1.3^{E} (0.78 - 1.8)	5.0^{E} (1.6 - 8.5)
Females, 20–39	1	651	64.21	—	<LOD	<LOD	0.94 (0.70 - 1.2)	3.5^{E} (2.0 - 4.9)
Females, 20–39	2	185	30.81	0.65 (0.49 - 0.86)	<LOD	0.60^{E} (0.31 - 0.90)	1.1^{E} (0.39 - 1.8)	x
Females, 40–59	1	645	65.58	—	<LOD	<LOD	0.99 (0.69 - 1.3)	5.2^{E} (2.5 - 7.9)
Females, 40–59	2	160	29.38	0.70 (0.51 - 0.95)	<LOD	0.66 (0.43 - 0.90)	1.1 (0.79 - 1.5)	x
Females, 60–79	1	539	62.15	—	<LOD	<LOD	0.94 (0.77 - 1.1)	3.6 (2.4 - 4.7)
Females, 60–79	2	146	29.45	0.63 (0.45 - 0.88)	<LOD	0.49^{E} (<LOD - 0.72)	1.3^{E} (0.73 - 1.8)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.4.5.4

Diethylthiophosphate (DETP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5460	59.93	—	<LOD	<LOD	0.85 (0.62 - 1.1)	4.2 (3.4 - 5.1)
Total, 6–79	2	1990	25.58	0.58 (0.52 - 0.65)	<LOD	0.55 (0.45 - 0.65)	1.2 (1.1 - 1.4)	3.9 (3.2 - 4.5)
Males, Total 6–79	1	2649	58.70	—	<LOD	<LOD	0.72 (0.53 - 0.92)	3.5 (2.9 - 4.0)
Males, Total 6–79	2	1003	25.12	0.48 (0.42 - 0.55)	<LOD	0.41 (0.31 - 0.52)	0.96 (0.81 - 1.1)	3.0^{E} (1.8 - 4.2)
Females, Total 6–79	1	2811	61.08	—	<LOD	<LOD	0.99 (0.72 - 1.3)	4.7 (3.8 - 5.7)
Females, Total 6–79	2	987	26.04	0.71 (0.59 - 0.86)	<LOD	0.68 (0.54 - 0.83)	1.4 (1.1 - 1.7)	4.8^{E} (2.4 - 7.3)

a For the purpose of total population comparisons, only values from participants aged 6–79 were included as participants under the age of 6 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.5.5

Diethylthiophosphate (DETP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2501	23.35	0.61 (0.55 - 0.67)	<LOD	0.59 (0.50 - 0.68)	1.3 (1.2 - 1.4)	4.2 (3.6 - 4.8)
3–5[b]	1							
3–5	2	511	14.68	1.7 (1.5 - 2.0)	<LOD	1.7 (1.4 - 2.0)	3.5 (2.9 - 4.1)	9.6^{E} (5.1 - 14)
6–11	1	1026	54.87	—	<LOD	<LOD	1.3^{E} (0.72 - 1.8)	6.4 (4.3 - 8.4)
6–11	2	506	22.13	0.93 (0.78 - 1.1)	<LOD	0.89 (0.75 - 1.0)	1.9 (1.5 - 2.3)	F
12–19	1	977	54.66	—	<LOD	<LOD	0.78 (0.56 - 0.99)	3.1 (2.1 - 4.1)
12–19	2	502	22.91	0.47 (0.40 - 0.56)	<LOD	0.48 (0.37 - 0.59)	0.93 (0.77 - 1.1)	2.8^{E} (1.6 - 4.1)
20–39	1	1159	64.37	—	<LOD	<LOD	0.67 (0.42 - 0.91)	3.0 (1.9 - 4.1)
20–39	2	347	29.39	0.46 (0.40 - 0.53)	<LOD	0.39 (<LOD - 0.49)	1.0 (0.85 - 1.2)	3.7^{E} (2.4 - 5.1)
40–59	1	1218	66.01	—	<LOD	<LOD	0.77^{E} (0.40 - 1.1)	5.4^{E} (3.4 - 7.5)
40–59	2	350	28.57	0.62 (0.48 - 0.80)	<LOD	0.62 (0.45 - 0.80)	1.3^{E} (0.71 - 1.8)	4.0^{E} (<LOD - 6.2)
60–79	1	1080	57.87	—	<LOD	<LOD	1.2 (0.93 - 1.4)	4.1 (2.7 - 5.4)
60–79	2	285	28.07	0.72 (0.58 - 0.88)	<LOD	0.69 (0.54 - 0.85)	1.4 (1.1 - 1.6)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.4.5.6

Diethylthiophosphate (DETP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1257	22.91	0.50 (0.44 - 0.57)	<LOD	0.44 (0.33 - 0.55)	1.0 (0.83 - 1.2)	3.3 (2.2 - 4.5)
Males, 6–11	1	523	54.11	—	<LOD	<LOD	1.3[E] (0.60 - 2.0)	6.7[E] (3.8 - 9.7)
Males, 6–11	2	259	22.78	0.86 (0.70 - 1.1)	<LOD	0.90 (0.58 - 1.2)	1.9 (1.4 - 2.4)	3.8 (3.3 - 4.3)
Males, 12–19	1	501	54.49	—	<LOD	<LOD	0.67 (0.49 - 0.85)	3.0[E] (0.91 - 5.1)
Males, 12–19	2	249	23.29	0.45 (0.37 - 0.55)	<LOD	0.48 (0.36 - 0.61)	0.81 (0.56 - 1.1)	F
Males, 20–39	1	510	64.31	—	<LOD	<LOD	0.55[E] (0.34 - 0.77)	2.0 (1.5 - 2.6)
Males, 20–39	2	163	27.61	0.34 (0.26 - 0.45)	<LOD	0.32 (<LOD - 0.42)	0.65[E] (0.34 - 0.96)	x
Males, 40–59	1	574	66.38	—	<LOD	<LOD	0.64[E] (0.39 - 0.89)	3.7 (2.5 - 4.9)
Males, 40–59	2	192	27.60	0.50 (0.37 - 0.67)	<LOD	0.44[E] (0.22 - 0.66)	0.98 (0.65 - 1.3)	x
Males, 60–79	1	541	53.60	—	<LOD	<LOD	1.1 (0.82 - 1.3)	3.8[E] (1.3 - 6.3)
Males, 60–79	2	140	26.43	0.64 (0.47 - 0.86)	<LOD	0.55 (0.37 - 0.74)	1.3[E] (<LOD - 1.8)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1244	23.79	0.73 (0.61 - 0.88)	<LOD	0.69 (0.56 - 0.82)	1.5 (1.1 - 1.9)	5.2[E] (2.9 - 7.6)
Females, 6–11	1	503	55.67	—	<LOD	<LOD	1.3[E] (0.55 - 2.0)	6.0[E] (3.5 - 8.5)
Females, 6–11	2	247	21.46	1.0 (0.76 - 1.4)	<LOD	0.86 (0.69 - 1.0)	1.8[E] (0.93 - 2.6)	F
Females, 12–19	1	476	54.83	—	<LOD	<LOD	0.88 (0.59 - 1.2)	3.3 (2.3 - 4.2)
Females, 12–19	2	253	22.53	0.50 (0.40 - 0.62)	<LOD	0.48 (0.34 - 0.62)	0.98 (0.80 - 1.2)	3.0[E] (1.5 - 4.5)
Females, 20–39	1	649	64.41	—	<LOD	<LOD	0.92[E] (0.51 - 1.3)	4.2 (2.8 - 5.6)
Females, 20–39	2	184	30.98	0.61 (0.47 - 0.80)	<LOD	0.60[E] (0.33 - 0.87)	1.3[E] (0.69 - 2.0)	x
Females, 40–59	1	644	65.68	—	<LOD	<LOD	1.0[E] (0.50 - 1.5)	7.1[E] (4.0 - 10)
Females, 40–59	2	158	29.75	0.78[E] (0.52 - 1.2)	<LOD	0.69[E] (0.43 - 0.94)	1.5[E] (0.62 - 2.5)	x
Females, 60–79	1	539	62.15	—	<LOD	<LOD	1.2 (0.91 - 1.5)	4.5 (3.2 - 5.8)
Females, 60–79	2	145	29.66	0.80 (0.56 - 1.1)	<LOD	0.75[E] (<LOD - 1.0)	1.4[E] (0.67 - 2.0)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.4.6 Diethyldithiophosphate (DEDTP)

Table 14.4.6.1

Diethyldithiophosphate (DEDTP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5475	96.84	—	<LOD	<LOD	<LOD	<LOD
Total, 6–79	2	2033	97.15	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–79	1	2659	96.35	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–79	2	1019	96.37	—	<LOD	<LOD	<LOD	F
Females, Total 6–79	1	2816	97.30	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–79	2	1014	97.93	—	<LOD	<LOD	<LOD	<LOD

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

F Data is too unreliable to be published.

Table 14.4.6.2

Diethyldithiophosphate (DEDTP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2557	97.38	—	<LOD	<LOD	<LOD	<LOD
3–5[b]	1							
3–5	2	524	98.28	—	<LOD	<LOD	<LOD	<LOD
6–11	1	1029	96.21	—	<LOD	<LOD	<LOD	<LOD
6–11	2	516	97.48	—	<LOD	<LOD	<LOD	F
12–19	1	980	96.12	—	<LOD	<LOD	<LOD	<LOD
12–19	2	511	97.06	—	<LOD	<LOD	<LOD	<LOD
20–39	1	1163	97.08	—	<LOD	<LOD	<LOD	<LOD
20–39	2	356	96.35	—	<LOD	<LOD	<LOD	<LOD
40–59	1	1223	97.30	—	<LOD	<LOD	<LOD	<LOD
40–59	2	360	97.22	—	<LOD	<LOD	<LOD	<LOD
60–79	1	1080	97.31	—	<LOD	<LOD	<LOD	<LOD
60–79	2	290	97.59	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

F Data is too unreliable to be published.

Table 14.4.6.3

Diethyldithiophosphate (DEDTP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1279	96.79	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	1	525	96.19	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	262	97.33	—	<LOD	<LOD	<LOD	F
Males, 12–19	1	503	95.83	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	97.25	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	1	512	97.07	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	167	94.61	—	<LOD	<LOD	<LOD	x
Males, 40–59	1	578	96.89	—	<LOD	<LOD	<LOD	<LOD
Males, 40–59	2	194	95.36	—	<LOD	<LOD	<LOD	x
Males, 60–79	1	541	95.75	—	<LOD	<LOD	<LOD	<LOD
Males, 60–79	2	141	96.45	—	<LOD	<LOD	<LOD	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1278	97.97	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	1	504	96.23	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	254	97.64	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	1	477	96.44	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	256	96.88	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	1	651	97.08	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	97.88	—	<LOD	<LOD	<LOD	x
Females, 40–59	1	645	97.67	—	<LOD	<LOD	<LOD	<LOD
Females, 40–59	2	166	99.40	—	<LOD	<LOD	<LOD	x
Females, 60–79	1	539	98.89	—	<LOD	<LOD	<LOD	<LOD
Females, 60–79	2	149	98.66	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.4.6.4

Diethyldithiophosphate (DEDTP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5461	97.09	—	<LOD	<LOD	<LOD	<LOD
Total, 6–79	2	2024	97.58	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–79	1	2650	96.68	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–79	2	1016	96.65	—	<LOD	<LOD	<LOD	0.55 (<LOD - 0.73)
Females, Total 6–79	1	2811	97.47	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–79	2	1008	98.51	—	<LOD	<LOD	<LOD	<LOD

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 14.4.6.5

Diethyldithiophosphate (DEDTP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2547	97.76	—	<LOD	<LOD	<LOD	<LOD
3–5[b]	1							
3–5	2	523	98.47	—	<LOD	<LOD	<LOD	<LOD
6–11	1	1026	96.49	—	<LOD	<LOD	<LOD	<LOD
6–11	2	514	97.86	—	<LOD	<LOD	<LOD	0.73[E] (<LOD - 1.2)
12–19	1	978	96.32	—	<LOD	<LOD	<LOD	<LOD
12–19	2	509	97.45	—	<LOD	<LOD	<LOD	<LOD
20–39	1	1159	97.41	—	<LOD	<LOD	<LOD	<LOD
20–39	2	354	96.89	—	<LOD	<LOD	<LOD	<LOD
40–59	1	1218	97.70	—	<LOD	<LOD	<LOD	<LOD
40–59	2	358	97.77	—	<LOD	<LOD	<LOD	<LOD
60–79	1	1080	97.31	—	<LOD	<LOD	<LOD	<LOD
60–79	2	289	97.92	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 14.4.6.6

Diethyldithiophosphate (DEDTP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th[b] (95%CI)	50th[b] (95%CI)	75th[b] (95%CI)	95th[b] (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1275	97.10	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	1	523	96.56	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	261	97.70	—	<LOD	<LOD	<LOD	0.71[E] (<LOD - 1.1)
Males, 12–19	1	502	96.02	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	97.64	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	1	510	97.45	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	166	95.18	—	<LOD	<LOD	<LOD	x
Males, 40–59	1	574	97.56	—	<LOD	<LOD	<LOD	<LOD
Males, 40–59	2	194	95.36	—	<LOD	<LOD	<LOD	x
Males, 60–79	1	541	95.75	—	<LOD	<LOD	<LOD	<LOD
Males, 60–79	2	141	96.45	—	<LOD	<LOD	<LOD	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1272	98.43	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	1	503	96.42	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	253	98.02	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	1	476	96.64	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	255	97.25	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	1	649	97.38	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	188	98.40	—	<LOD	<LOD	<LOD	x
Females, 40–59	1	644	97.83	—	<LOD	<LOD	<LOD	<LOD
Females, 40–59	2	164	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	1	539	98.89	—	<LOD	<LOD	<LOD	<LOD
Females, 60–79	2	148	99.32	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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14.5 PYRETHROID METABOLITES

Pyrethrins are naturally occurring compounds found in certain chrysanthemum flowers (ATSDR, 2003). They have been used for their insecticidal properties since the early 1800s in Asia to control ticks and various insects, such as fleas and mosquitoes (ATSDR, 2003). Pyrethroids are synthetic versions of pyrethrins that have been structurally altered to improve their efficacy as pesticides by increasing their stability in the environment and their toxicity (ATSDR, 2003; EPA, 2012). Many commercial pyrethroid pesticides currently are registered for use in Canada, as listed in Table 14.5.1 (Health Canada, 2012a).

Pyrethroids enter the environment primarily because of their use as pesticides; however, they break down rapidly and, as a result, only trace amounts of the chemicals are typically found in air, water, soil, and food (ATSDR, 2003). Pyrethroids degrade to carboxylic and phenoxybenzoic metabolites in the environment, and these metabolites have been measured in dust collected from homes and daycare centres (Starr et al., 2008). Pyrethroids bind strongly to soil particles, thus they usually do not leach into the groundwater, but rather remain in the soil (ATSDR, 2003).

Pyrethroid pesticides are used in Canada for insect control on agricultural crops and on turf; in orchards, nurseries, and greenhouses; as a general indoor and outdoor residential insecticide for controlling crawling and flying insect pests; for controlling adult mosquitoes around buildings; in cattle ear tags; for controlling mites in bee colonies; and for flea and tick control on pets (Health Canada, 2004; Health Canada, 2012a). In malaria-endemic zones, pyrethroids are used to impregnate mosquito nets and clothing for the prevention of malaria (Health Canada, 2004). The use of pyrethrins and pyrethroids has increased during the past decade with the declining use of organophosphate pesticides that are more acutely toxic to birds and mammals than the pyrethroids (EPA, 2012).

Permethrin is the most widely used pyrethroid pesticide in Canada and is found in over 250 registered pesticide products (CCME, 2006; Health Canada, 2012a). It is used for a variety of agricultural, livestock, forestry, and residential insect control applications. In addition to the pesticide uses, permethrin is used in medications for the treatment of scabies (Health Canada, 2012b). Cyfluthrin is used as an agricultural and indoor surface insecticide for the control of crawling and flying insect pests (Health Canada, 2012a). Cypermethrin and lambda-cyhalothrin have agricultural and livestock uses. Deltamethrin is used in several agricultural applications, on turf, and in greenhouses; it is also used to treat sleeping areas and clothing in malaria-affected countries (Health Canada, 2004; Health Canada, 2009). D-phenothrin is used primarily in residential settings, whereas fluvalinate-tau is used to control mites in bee colonies (Health Canada, 2009).

The primary routes of exposure for the general population are through the use of products that contain pyrethroids, such as household insecticides and pet sprays, and through the ingestion of pyrethroid residues in food (EPA, 2009a).

Pyrethroid pesticides are rapidly metabolized and eliminated from the body through hydrolysis, oxidation, and conjugation. Following oral ingestion, inhalation, or dermal exposure, pyrethroids are metabolized into carboxylic and phenoxybenzoic acids and excreted with urine. Pyrethroids and metabolites can be measured in blood and urine, and are reflective of recent exposure to the parent compound or the metabolite in the environment (ATSDR, 2003; CDC, 2009; Kuhn et al., 1999; Starr et al., 2008). Urinary metabolites of pyrethroids can be specific to one pyrethroid or common to several pyrethroids. Table 14.5.1 outlines the pyrethroid metabolites measured as part of this survey and their corresponding parent compounds.

Table 14.5.1

Pyrethroid pesticide metabolites measured in the Canadian Health Measures Survey cycle 2 (2009–2011) and their parent pesticide compounds.

Pyrethroid pesticide (CASRN)	Metabolite (CASRN)
Cyfluthrin (68359-37-5)	4-F-3-PBA: 4-fluoro-3-phenoxybenzoic acid (77279-89-1)
Deltamethrin (52918-63-5)	*cis*-DBCA: *cis*-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid (63597-73-9)
Cyfluthrin (68359-37-5) Permethrin (52645-53-1) Cypermethrin (52315-07-8)	*cis*-DCCA: *cis*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (55701-05-8)
Cyfluthrin (68359-37-5) Permethrin (52645-53-1) Cypermethrin (52315-07-8)	*trans*-DCCA: *trans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (55701-03-6)
Cypermethrin (52315-07-8) Deltamethrin (52918-63-5) Permethrin (52645-53-1) lambda-Cyhalothrin (91465-08-6) D-Phenothrin (26046-85-5) Fluvalinate-tau (102851-06-9)	3-PBA: 3-phenoxybenzoic acid (3739-38-6)

(Barr & Needham, 2002; CDC, 2009; Fortin et al., 2008; Starr et al., 2008)

Pyrethroids, much like the naturally occurring pyrethrins, primarily affect the nervous system of insects and mammals (Davies et al., 2007). They act on the axons in the peripheral and central nervous systems by prolonging the opening time of small conductance sodium channels, leading to membrane depolarizations and excess excitability. This action causes paralysis in target insect pests, eventually resulting in death. Pyrethroids are over 2,000 times more toxic to insects than mammals because insects have an increased sodium channel sensitivity, a smaller body size, and a lower body temperature (Bradberry et al., 2005). Mammals are also able to quickly metabolize pyrethroids into their inactive forms and eliminate them from the body (Health Canada, 2009).

Adverse effects can include dizziness, nausea, headaches, tremor, salivation, involuntary movements, and seizures; very high exposures may result in unconsciousness (ATSDR, 2003; CDC, 2005). Studies indicate that long-term exposures to low levels of pyrethroids do not cause neurological effects in mammals, primarily because of the rapid metabolism and elimination of these compounds from the body (ATSDR, 2003). Allergic reactions in humans have been reported following exposure to pyrethroids; however, the United States Environmental Protection Agency (EPA) found no clear and consistent pattern of effects reported to indicate conclusively whether there is an association between pyrethroid exposure and asthma and allergies (EPA, 2009b; Moretto, 1991; Salome et al., 2000; Vanden Driessche et al., 2010). The International Agency for Research on Cancer has classified permethrin as Group 3, not classifiable as to its carcinogenicity to humans because of a lack of evidence (IARC, 1991). The EPA has classified permethrin as likely to be carcinogenic in humans by the oral route of exposure (EPA, 2009a).

The sale and use of pyrethroid pesticides is regulated in Canada by the Pest Management Regulatory Agency (PMRA) under the *Pest Control Products Act* (Canada, 2006). PMRA evaluates the toxicity and potential exposure in order to determine whether a pesticide should be registered for a specific use. As part of this registration process, PMRA specifies maximum residue limits of pesticides in food. Maximum residue limits exist for several pyrethroid pesticides in food including cyfluthrin, cypermethrin, and permethrin (Health Canada, 2011a). Many of the pyrethroids currently registered for use in Canada are under re-evaluation by PMRA (Health Canada, 2011b).

Pyrethroid metabolites were measured in 89 children (6 to 12 years) and 81 adults (18 to 64 years) in the province of Quebec in 2005 (Fortin et al., 2008). Metabolites were identified in urine collected for 12 hours from children and in urine collected for two consecutive 12-hour periods in adults. In children, the median and 95th percentile concentrations were <0.005 µg/L and 0.02 µg/L, respectively, for 4-F-3-PBA; <0.006 µg/L and 0.09 µg/L, respectivley, for *cis*-DBCA; 0.10 µg/L and 0.76 µg/L, respectively, for *cis*-DCCA; 0.24 µg/L and 4.10 µg/L, respectively, for *trans*-DCCA; and 0.20 µg/L and 1.54 µg/L, respectively, for 3-PBA. In adults, the median and 95th percentile concentrations were <0.005 µg/L and 0.03 µg/L, respectively, for 4-F-3-PBA; <0.006 µg/L and 0.14 µg/L, respectively, for *cis*-DBCA; 0.10 µg/L and 1.15 µg/L, respectively, for *cis*-DCCA; 0.25 µg/L and 3.48 µg/L, respectively, for *trans*-DCCA; and 0.17 µg/L and 4.23 µg/L, respectively, for 3-PBA (Fortin et al., 2008).

Five pyrethroid metabolites (see Table 14.5.1) were measured in the urine of all Canadian Health Measures Survey participants aged 6 to 79 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). Data from these cycles are presented as both µg/L and µg/g creatinine (Tables 14.5.1.1 to 14.5.5.6). Finding a measurable amount of pyrethroid metabolites in urine is an indicator of exposure to pyrethroid pesticides and does not necessarily mean that an adverse health effect will occur.

14.5.1 4-Fluoro-3-Phenoxybenzoic Acid (4-F-3-PBA)

Table 14.5.1.1

4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5224	56.45	—	<LOD	<LOD	0.0099 (<LOD - 0.013)	0.076 (0.054 - 0.098)
Total, 6–79	2	2022	43.37	—	<LOD	0.0091 (0.0080 - 0.010)	0.018 (0.012 - 0.023)	0.11^{E} (0.035 - 0.18)
Males, Total 6–79	1	2529	54.49	—	<LOD	<LOD	0.011 (<LOD - 0.015)	0.091^{E} (0.049 - 0.13)
Males, Total 6–79	2	1012	44.07	—	<LOD	0.0090 (<LOD - 0.011)	0.018 (0.012 - 0.024)	0.10^{E} (0.039 - 0.17)
Females, Total 6–79	1	2695	58.29	—	<LOD	<LOD	0.0098 (0.0084 - 0.011)	0.058 (0.045 - 0.071)
Females, Total 6–79	2	1010	42.67	—	<LOD	0.0092 (0.0083 - 0.010)	0.018^{E} (0.010 - 0.026)	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.1.2

4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2539	44.70	—	<LOD	0.0091 (<LOD - 0.010)	0.018 (0.013 - 0.023)	0.11[E] (0.040 - 0.17)
3–5[b]	1							
3–5	2	517	49.90	—	<LOD	<LOD	0.015[E] (<LOD - 0.023)	0.050 (0.032 - 0.067)
6–11	1	998	57.52	—	<LOD	<LOD	0.0096 (0.0093 - 0.0098)	F
6–11	2	514	43.77	—	<LOD	0.0087 (<LOD - 0.011)	0.015[E] (0.0091 - 0.020)	0.056[E] (0.028 - 0.085)
12–19	1	947	49.10	—	<LOD	F	0.011 (<LOD - 0.015)	0.060[E] (0.017 - 0.10)
12–19	2	510	41.76	—	<LOD	0.0090 (<LOD - 0.011)	0.015 (0.011 - 0.019)	F
20–39	1	1100	54.82	—	<LOD	<LOD	0.011[E] (<LOD - 0.015)	0.089[E] (0.030 - 0.15)
20–39	2	352	43.18	—	<LOD	0.0093 (<LOD - 0.012)	0.019[E] (<LOD - 0.030)	0.11[E] (0.033 - 0.19)
40–59	1	1161	59.09	—	<LOD	<LOD	0.010[E] (<LOD - 0.014)	0.079[E] (0.048 - 0.11)
40–59	2	357	41.46	—	<LOD	0.0094 (0.0083 - 0.010)	0.026[E] (0.011 - 0.040)	F
60–79	1	1018	61.00	—	<LOD	<LOD	0.0095 (<LOD - 0.011)	0.069[E] (0.021 - 0.12)
60–79	2	289	48.10	—	<LOD	<LOD	F	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.1.3

4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1268	44.16	—	<LOD	0.0090 (<LOD - 0.012)	0.018 (0.012 - 0.023)	0.10[E] (0.044 - 0.16)
Males, 6–11	1	515	56.31	—	<LOD	<LOD	0.0098 (0.0089 - 0.011)	0.053[E] (0.022 - 0.084)
Males, 6–11	2	261	44.44	—	<LOD	0.0092 (<LOD - 0.011)	0.017[E] (<LOD - 0.026)	F
Males, 12–19	1	485	47.22	—	<LOD	0.0083[E] (<LOD - 0.011)	0.013 (0.0083 - 0.017)	0.061[E] (0.032 - 0.091)
Males, 12–19	2	255	45.49	—	<LOD	F	0.011[E] (<LOD - 0.015)	0.040[E] (0.023 - 0.056)
Males, 20–39	1	484	52.89	—	<LOD	<LOD	0.014[E] (<LOD - 0.021)	F
Males, 20–39	2	162	43.83	—	<LOD	0.0091[E] (<LOD - 0.013)	0.017[E] (0.0091 - 0.024)	x
Males, 40–59	1	541	57.30	—	<LOD	<LOD	0.011[E] (<LOD - 0.017)	0.10[E] (0.047 - 0.16)
Males, 40–59	2	192	39.58	0.014 (0.0098 - 0.020)	<LOD	0.0094 (<LOD - 0.011)	0.030[E] (0.012 - 0.049)	x
Males, 60–79	1	504	58.13	—	<LOD	<LOD	0.0096 (<LOD - 0.011)	0.068[E] (0.030 - 0.11)
Males, 60–79	2	142	47.18	—	<LOD	<LOD	0.012[E] (<LOD - 0.019)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1271	45.24	—	<LOD	0.0092 (0.0083 - 0.010)	0.018[E] (0.011 - 0.025)	F
Females, 6–11	1	483	58.80	—	<LOD	<LOD	0.0094 (0.0090 - 0.0098)	F
Females, 6–11	2	253	43.08	—	<LOD	F	0.011[E] (<LOD - 0.015)	0.046[E] (0.029 - 0.063)
Females, 12–19	1	462	51.08	—	<LOD	<LOD	0.0099 (<LOD - 0.013)	F
Females, 12–19	2	255	38.04	0.012 (0.0088 - 0.017)	<LOD	0.0094 (0.0085 - 0.010)	0.018[E] (<LOD - 0.028)	F
Females, 20–39	1	616	56.33	—	<LOD	<LOD	0.0098 (<LOD - 0.012)	0.066[E] (0.035 - 0.098)
Females, 20–39	2	190	42.63	—	<LOD	0.0095 (<LOD - 0.011)	0.025[E] (0.011 - 0.040)	x
Females, 40–59	1	620	60.65	—	<LOD	<LOD	0.0099 (<LOD - 0.013)	0.057[E] (0.034 - 0.079)
Females, 40–59	2	165	43.64	—	<LOD	0.0094 (<LOD - 0.011)	F	x
Females, 60–79	1	514	63.81	—	<LOD	<LOD	0.0094 (<LOD - 0.012)	F
Females, 60–79	2	147	48.98	—	<LOD	<LOD	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.5.1.4

4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5210	56.60	—	<LOD	<LOD	0.017 (<LOD - 0.020)	0.072^{E} (0.038 - 0.10)
Total, 6–79	2	2013	43.57	—	<LOD	0.0094 (0.0078 - 0.011)	0.019 (0.015 - 0.022)	F
Males, Total 6–79	1	2520	54.68	—	<LOD	<LOD	0.014 (<LOD - 0.017)	F
Males, Total 6–79	2	1009	44.20	—	<LOD	0.0074 (<LOD - 0.0089)	0.016 (0.012 - 0.020)	F
Females, Total 6–79	1	2690	58.40	—	<LOD	<LOD	0.020 (0.017 - 0.023)	0.072^{E} (0.043 - 0.10)
Females, Total 6–79	2	1004	42.93	—	<LOD	0.012 (0.0096 - 0.014)	0.021 (0.016 - 0.025)	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.1.5

4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2529	44.88	—	<LOD	0.0096 (<LOD - 0.011)	0.019 (0.016 - 0.022)	F
3–5[b]	1							
3–5	2	516	50.00	—	<LOD	<LOD	0.028^{E} (<LOD - 0.040)	0.090^{E} (0.057 - 0.12)
6–11	1	995	57.69	—	<LOD	<LOD	0.018 (0.015 - 0.020)	0.070^{E} (0.042 - 0.099)
6–11	2	512	43.95	—	<LOD	0.010 (<LOD - 0.012)	0.017 (0.011 - 0.022)	0.066^{E} (0.024 - 0.11)
12–19	1	945	49.21	—	<LOD	<LOD (<LOD - 0.0087)	0.013 (<LOD - 0.016)	0.045^{E} (0.016 - 0.074)
12–19	2	508	41.93	—	<LOD	0.0067 (<LOD - 0.0080)	0.012 (0.0096 - 0.015)	F
20–39	1	1096	55.02	—	<LOD	<LOD	0.017 (<LOD - 0.021)	F
20–39	2	350	43.43	—	<LOD	0.0087^{E} (<LOD - 0.012)	0.018^{E} (<LOD - 0.027)	F
40–59	1	1156	59.34	—	<LOD	<LOD	0.018 (<LOD - 0.022)	0.079^{E} (0.039 - 0.12)
40–59	2	355	41.69	—	<LOD	0.012 (0.0096 - 0.015)	0.022 (0.017 - 0.027)	F
60–79	1	1018	61.00	—	<LOD	<LOD	0.018 (<LOD - 0.023)	0.095^{E} (0.026 - 0.16)
60–79	2	288	48.26	—	<LOD	<LOD	0.018^{E} (<LOD - 0.029)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.1.6

4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1264	44.30	—	<LOD	0.0077 (<LOD - 0.0093)	0.017 (0.013 - 0.020)	F
Males, 6–11	1	513	56.53	—	<LOD	<LOD	0.018 (0.014 - 0.022)	0.072[E] (0.036 - 0.11)
Males, 6–11	2	260	44.62	—	<LOD	0.011 (<LOD - 0.014)	0.018[E] (<LOD - 0.027)	F
Males, 12–19	1	484	47.31	—	<LOD	0.0080 (<LOD - 0.0096)	0.014 (0.011 - 0.018)	0.041 (0.031 - 0.051)
Males, 12–19	2	254	45.67	—	<LOD	<LOD (<LOD - 0.0068)	0.011 (<LOD - 0.014)	0.024[E] (0.015 - 0.034)
Males, 20–39	1	482	53.11	—	<LOD	<LOD	0.015[E] (<LOD - 0.021)	F
Males, 20–39	2	161	44.10	—	<LOD	0.0055 (<LOD - 0.0067)	F	x
Males, 40–59	1	537	57.73	—	<LOD	<LOD	0.014 (<LOD - 0.016)	F
Males, 40–59	2	192	39.58	0.012 (0.0095 - 0.015)	<LOD	0.011 (<LOD - 0.014)	0.020 (0.015 - 0.026)	x
Males, 60–79	1	504	58.13	—	<LOD	<LOD	0.013 (<LOD - 0.017)	0.058[E] (0.034 - 0.082)
Males, 60–79	2	142	47.18	—	<LOD	<LOD	0.016 (<LOD - 0.019)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1265	45.45	—	<LOD	0.012 (0.0097 - 0.014)	0.021 (0.017 - 0.025)	F
Females, 6–11	1	482	58.92	—	<LOD	<LOD	0.017 (0.014 - 0.020)	0.063[E] (<LOD - 0.10)
Females, 6–11	2	252	43.25	—	<LOD	<LOD (<LOD - 0.012)	0.015 (<LOD - 0.020)	0.056[E] (0.034 - 0.077)
Females, 12–19	1	461	51.19	—	<LOD	<LOD	0.012 (<LOD - 0.015)	F
Females, 12–19	2	254	38.19	0.010 (0.0079 - 0.013)	<LOD	0.0086 (0.0068 - 0.010)	0.017[E] (<LOD - 0.024)	0.099[E] (<LOD - 0.17)
Females, 20–39	1	614	56.51	—	<LOD	<LOD	0.019 (<LOD - 0.024)	0.072[E] (0.037 - 0.11)
Females, 20–39	2	189	42.86	—	<LOD	0.013 (<LOD - 0.017)	0.021[E] (0.0060 - 0.036)	x
Females, 40–59	1	619	60.74	—	<LOD	<LOD	0.022 (<LOD - 0.026)	0.070 (0.048 - 0.091)
Females, 40–59	2	163	44.17	—	<LOD	0.013 (<LOD - 0.016)	0.022[E] (<LOD - 0.030)	x
Females, 60–79	1	514	63.81	—	<LOD	<LOD	0.022 (<LOD - 0.030)	F
Females, 60–79	2	146	49.32	—	<LOD	<LOD	0.021[E] (<LOD - 0.030)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.5.2 *cis*-3-(2,2-Dibromovinyl)-2,2-Dimethylcyclopropane Carboxylic Acid (*cis*-DBCA)

■ Table 14.5.2.1

cis-3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DBCA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5022	50.36	—	<LOD	<LOD	0.019 (0.014 - 0.025)	0.073 (0.060 - 0.087)
Total, 6–79	2	2013	37.75	0.012 (0.010 - 0.014)	<LOD	0.0094 (0.0082 - 0.011)	0.030 (0.025 - 0.036)	0.15^{E} (0.073 - 0.23)
Males, Total 6–79	1	2433	49.65	—	<LOD	<LOD	0.020 (0.019 - 0.020)	0.074 (0.060 - 0.089)
Males, Total 6–79	2	1013	36.72	0.012 (0.010 - 0.015)	<LOD	0.0096 (0.0070 - 0.012)	0.034^{E} (0.021 - 0.046)	0.14^{E} (0.046 - 0.24)
Females, Total 6–79	1	2589	51.02	—	<LOD	<LOD	0.019^{E} (0.0068 - 0.031)	0.072 (0.052 - 0.092)
Females, Total 6–79	2	1000	38.80	0.011 (0.0090 - 0.014)	<LOD	0.0092 (0.0068 - 0.012)	0.028 (0.020 - 0.035)	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

■ Table 14.5.2.2

cis-3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DBCA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2535	37.24	0.012 (0.010 - 0.014)	<LOD	0.0094 (0.0084 - 0.010)	0.030 (0.025 - 0.036)	0.15^{E} (0.076 - 0.23)
3–5[b]	1							
3–5	2	522	35.25	0.014 (0.010 - 0.018)	<LOD	F	0.031^{E} (0.017 - 0.044)	F
6–11	1	974	48.67	—	<LOD	<LOD	0.019^{E} (0.011 - 0.028)	0.097 (0.064 - 0.13)
6–11	2	513	33.33	0.015 (0.012 - 0.021)	<LOD	F	0.035 (0.024 - 0.045)	F
12–19	1	927	43.26	—	<LOD	0.0072^{E} (<LOD - 0.011)	0.020 (0.015 - 0.025)	0.085 (0.069 - 0.10)
12–19	2	507	34.12	0.014 (0.012 - 0.017)	<LOD	F	0.034 (0.027 - 0.042)	0.19 (0.14 - 0.24)
20–39	1	1055	52.13	—	<LOD	<LOD	0.017^{E} (<LOD - 0.028)	0.085^{E} (0.051 - 0.12)
20–39	2	355	39.44	0.012 (0.0086 - 0.016)	<LOD	F	0.033 (0.025 - 0.042)	F
40–59	1	1109	54.19	—	<LOD	<LOD	0.019 (0.013 - 0.025)	0.067 (0.056 - 0.077)
40–59	2	352	40.91	—	<LOD	0.0093 (0.0060 - 0.013)	0.027^{E} (0.012 - 0.042)	F
60–79	1	957	52.56	—	<LOD	<LOD	0.019 (0.015 - 0.024)	0.071 (0.052 - 0.091)
60–79	2	286	46.15	—	<LOD	0.0089^{E} (<LOD - 0.013)	0.025 (0.022 - 0.028)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.2.3

cis-3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DBCA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1272	35.77	0.012 (0.010 - 0.015)	<LOD	0.0096 (0.0068 - 0.012)	0.033^{E} (0.021 - 0.045)	0.14^{E} (0.048 - 0.23)
Males, 6–11	1	501	50.70	—	<LOD	<LOD	0.019^{E} (0.011 - 0.028)	0.074 (0.055 - 0.094)
Males, 6–11	2	261	34.10	0.016 (0.012 - 0.023)	<LOD	F	0.036^{E} (0.015 - 0.057)	F
Males, 12–19	1	476	42.44	—	<LOD	0.0082 (<LOD - 0.011)	0.022 (0.018 - 0.026)	0.083 (0.067 - 0.098)
Males, 12–19	2	254	35.83	0.013 (0.0096 - 0.017)	<LOD	F	0.031^{E} (0.017 - 0.045)	0.14^{E} (0.070 - 0.20)
Males, 20–39	1	463	50.97	—	<LOD	<LOD	F	0.056^{E} (0.023 - 0.090)
Males, 20–39	2	167	39.52	0.0093^{E} (0.0061 - 0.014)	<LOD	F	F	x
Males, 40–59	1	513	52.05	—	<LOD	<LOD	0.020 (0.015 - 0.025)	0.071 (0.052 - 0.089)
Males, 40–59	2	192	35.42	0.016^{E} (0.011 - 0.023)	<LOD	0.019^{E} (0.0087 - 0.030)	0.048^{E} (0.029 - 0.068)	x
Males, 60–79	1	480	51.88	—	<LOD	<LOD	0.020 (0.018 - 0.022)	0.073 (0.049 - 0.097)
Males, 60–79	2	139	41.73	—	<LOD	0.0093^{E} (<LOD - 0.015)	0.027 (0.017 - 0.036)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1263	38.72	0.011 (0.0092 - 0.013)	<LOD	0.0092 (0.0069 - 0.011)	0.028 (0.021 - 0.036)	F
Females, 6–11	1	473	46.51	—	<LOD	<LOD	0.019^{E} (0.0080 - 0.031)	0.11^{E} (0.065 - 0.16)
Females, 6–11	2	252	32.54	0.014^{E} (0.0098 - 0.021)	<LOD	F	0.033^{E} (0.021 - 0.045)	F
Females, 12–19	1	451	44.12	—	<LOD	0.0061^{E} (<LOD - 0.011)	0.020^{E} (0.011 - 0.028)	0.086^{E} (0.052 - 0.12)
Females, 12–19	2	253	32.41	0.016 (0.011 - 0.021)	<LOD	0.019^{E} (0.0072 - 0.031)	0.037 (0.027 - 0.046)	0.23^{E} (0.13 - 0.33)
Females, 20–39	1	592	53.04	—	<LOD	<LOD	F	0.093^{E} (0.056 - 0.13)
Females, 20–39	2	188	39.36	0.014 (0.010 - 0.020)	<LOD	0.019^{E} (<LOD - 0.033)	0.034 (0.024 - 0.045)	x
Females, 40–59	1	596	56.04	—	<LOD	<LOD	F	0.062 (0.046 - 0.079)
Females, 40–59	2	160	47.50	—	<LOD	<LOD	0.014^{E} (<LOD - 0.022)	x
Females, 60–79	1	477	53.25	—	<LOD	<LOD	0.019^{E} (0.0095 - 0.029)	0.067 (0.046 - 0.087)
Females, 60–79	2	147	50.34	—	<LOD	F	0.024 (0.019 - 0.028)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.5.2.4

cis-3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DBCA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5008	50.50	—	<LOD	<LOD	0.019 (0.016 - 0.022)	0.087 (0.066 - 0.11)
Total, 6–79	2	2004	37.92	0.011 (0.0096 - 0.013)	<LOD	0.011 (0.0086 - 0.013)	0.025 (0.020 - 0.029)	0.12^{E} (0.071 - 0.17)
Males, Total 6–79	1	2424	49.83	—	<LOD	<LOD	0.016 (0.013 - 0.019)	0.070 (0.051 - 0.090)
Males, Total 6–79	2	1010	36.83	0.010 (0.0083 - 0.012)	<LOD	0.0095 (0.0073 - 0.012)	0.024 (0.017 - 0.030)	0.12^{E} (0.055 - 0.18)
Females, Total 6–79	1	2584	51.12	—	<LOD	<LOD	0.024 (0.019 - 0.029)	0.096 (0.073 - 0.12)
Females, Total 6–79	2	994	39.03	0.013 (0.010 - 0.015)	<LOD	0.013 (0.0098 - 0.015)	0.026 (0.021 - 0.030)	0.14^{E} (0.059 - 0.22)

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.5.2.5

cis-3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DBCA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2525	37.39	0.012 (0.0099 - 0.014)	<LOD	0.011 (0.0088 - 0.013)	0.025 (0.021 - 0.030)	0.12^{E} (0.074 - 0.18)
3–5[b]	1							
3–5	2	521	35.32	0.024 (0.018 - 0.032)	<LOD	0.020^{E} (<LOD - 0.027)	0.052^{E} (0.026 - 0.078)	F
6–11	1	971	48.82	—	<LOD	<LOD	0.025 (0.020 - 0.029)	0.13^{E} (0.073 - 0.19)
6–11	2	511	33.46	0.018 (0.013 - 0.024)	<LOD	0.016^{E} (<LOD - 0.022)	0.038^{E} (0.023 - 0.052)	F
12–19	1	925	43.35	—	<LOD	0.0077 (<LOD - 0.0088)	0.016 (0.014 - 0.018)	0.071 (0.050 - 0.092)
12–19	2	505	34.26	0.011 (0.0092 - 0.012)	<LOD	0.010 (<LOD - 0.012)	0.025 (0.020 - 0.029)	0.13 (0.092 - 0.16)
20–39	1	1051	52.33	—	<LOD	<LOD	0.017 (<LOD - 0.021)	0.083^{E} (0.046 - 0.12)
20–39	2	353	39.66	0.0098 (0.0072 - 0.013)	<LOD	0.0093^{E} (<LOD - 0.013)	0.024 (0.016 - 0.032)	F
40–59	1	1104	54.44	—	<LOD	<LOD	0.019 (0.016 - 0.023)	0.087 (0.058 - 0.12)
40–59	2	350	41.14	—	<LOD	0.011 (0.0079 - 0.014)	0.024 (0.016 - 0.031)	0.12^{E} (0.047 - 0.19)
60–79	1	957	52.56	—	<LOD	<LOD	0.024 (0.017 - 0.031)	0.081 (0.061 - 0.10)
60–79	2	285	46.32	—	<LOD	0.013 (<LOD - 0.016)	0.025 (0.019 - 0.030)	0.18^{E} (0.079 - 0.28)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.2.6

cis-3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DBCA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1268	35.88	0.010 (0.0086 - 0.013)	<LOD	0.0098 (0.0076 - 0.012)	0.025 (0.018 - 0.031)	0.12[E] (0.050 - 0.19)
Males, 6–11	1	499	50.90	—	<LOD	<LOD	0.024 (0.017 - 0.031)	F
Males, 6–11	2	260	34.23	0.019 (0.013 - 0.027)	<LOD	0.014[E] (<LOD - 0.021)	0.045[E] (0.024 - 0.065)	F
Males, 12–19	1	475	42.53	—	<LOD	0.0073 (<LOD - 0.0083)	0.016 (0.013 - 0.019)	0.087 (0.058 - 0.12)
Males, 12–19	2	253	35.97	0.0091 (0.0068 - 0.012)	<LOD	0.0086[E] (<LOD - 0.012)	0.026[E] (0.017 - 0.036)	0.090 (0.063 - 0.12)
Males, 20–39	1	461	51.19	—	<LOD	<LOD	0.013 (<LOD - 0.016)	0.055[E] (0.024 - 0.087)
Males, 20–39	2	166	39.76	0.0065[E] (0.0043 - 0.0097)	<LOD	<LOD (<LOD - 0.0088)	F	x
Males, 40–59	1	509	52.46	—	<LOD	<LOD	0.016 (0.012 - 0.021)	0.067[E] (0.032 - 0.10)
Males, 40–59	2	192	35.42	0.013 (0.0095 - 0.019)	<LOD	0.014[E] (0.0084 - 0.020)	0.027[E] (0.010 - 0.044)	x
Males, 60–79	1	480	51.88	—	<LOD	<LOD	0.018 (0.013 - 0.023)	0.067 (0.050 - 0.084)
Males, 60–79	2	139	41.73	—	<LOD	0.0091[E] (<LOD - 0.014)	0.022[E] (0.013 - 0.032)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1257	38.90	0.013 (0.011 - 0.015)	<LOD	0.013 (0.010 - 0.015)	0.026 (0.021 - 0.030)	0.15[E] (0.072 - 0.22)
Females, 6–11	1	472	46.61	—	<LOD	<LOD	0.025 (0.019 - 0.031)	0.14[E] (0.055 - 0.23)
Females, 6–11	2	251	32.67	0.017[E] (0.011 - 0.025)	<LOD	0.017 (<LOD - 0.022)	0.031[E] (0.018 - 0.045)	F
Females, 12–19	1	450	44.22	—	<LOD	0.0080 (<LOD - 0.0095)	0.016 (0.014 - 0.019)	0.058 (0.043 - 0.074)
Females, 12–19	2	252	32.54	0.013 (0.010 - 0.016)	<LOD	0.012 (0.0076 - 0.016)	0.024 (0.019 - 0.029)	0.15[E] (0.082 - 0.22)
Females, 20–39	1	590	53.22	—	<LOD	<LOD	0.024[E] (<LOD - 0.034)	0.099[E] (0.060 - 0.14)
Females, 20–39	2	187	39.57	0.014 (0.011 - 0.020)	<LOD	0.015[E] (<LOD - 0.022)	0.028[E] (0.014 - 0.042)	x
Females, 40–59	1	595	56.13	—	<LOD	<LOD	0.025 (<LOD - 0.031)	0.092 (0.066 - 0.12)
Females, 40–59	2	158	48.10	—	<LOD	<LOD	0.019[E] (<LOD - 0.027)	x
Females, 60–79	1	477	53.25	—	<LOD	<LOD	0.031 (0.021 - 0.041)	0.094 (0.068 - 0.12)
Females, 60–79	2	146	50.68	—	<LOD	<LOD (<LOD - 0.018)	0.026 (0.017 - 0.035)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.5.3 *cis*-3-(2,2-Dichlorovinyl)-2,2-Dimethylcyclopropane Carboxylic Acid (*cis*-DCCA)

Table 14.5.3.1

cis-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5431	1.57	0.085 (0.070 - 0.10)	0.018 (0.014 - 0.023)	0.071 (0.057 - 0.086)	0.17 (0.13 - 0.21)	0.94 (0.72 - 1.2)
Total, 6–79	2	2033	0.74	0.13 (0.10 - 0.16)	0.025 (0.021 - 0.028)	0.096 (0.078 - 0.11)	0.29[E] (0.18 - 0.39)	2.2[E] (0.68 - 3.8)
Males, Total 6–79	1	2636	1.37	0.090 (0.073 - 0.11)	0.020 (0.015 - 0.025)	0.072 (0.057 - 0.088)	0.18 (0.13 - 0.22)	1.1 (0.78 - 1.4)
Males, Total 6–79	2	1019	0.88	0.11 (0.088 - 0.13)	0.024 (0.019 - 0.030)	0.089 (0.068 - 0.11)	0.23[E] (0.15 - 0.31)	1.3[E] (0.39 - 2.1)
Females, Total 6–79	1	2795	1.75	0.080 (0.066 - 0.098)	0.017 (0.012 - 0.021)	0.071 (0.055 - 0.086)	0.17 (0.13 - 0.21)	0.79 (0.63 - 0.95)
Females, Total 6–79	2	1014	0.59	0.15 (0.11 - 0.20)	0.026 (0.020 - 0.031)	0.10 (0.074 - 0.13)	0.36[E] (0.19 - 0.53)	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.3.2

cis-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2553	0.86	0.12 (0.10 - 0.15)	0.024 (0.021 - 0.028)	0.093 (0.076 - 0.11)	0.27[E] (0.17 - 0.37)	2.2[E] (0.78 - 3.6)
3–5[b]	1							
3–5	2	520	1.35	0.067 (0.049 - 0.091)	0.016 (0.011 - 0.022)	0.065 (0.047 - 0.082)	0.12 (0.078 - 0.15)	F
6–11	1	1026	2.73	0.054 (0.043 - 0.067)	0.014 (0.0099 - 0.018)	0.049 (0.038 - 0.060)	0.099 (0.087 - 0.11)	0.38[E] (0.18 - 0.57)
6–11	2	514	1.17	0.069 (0.059 - 0.082)	0.018 (0.014 - 0.022)	0.056 (0.046 - 0.065)	0.11 (0.082 - 0.14)	F
12–19	1	970	0.82	0.090 (0.067 - 0.12)	0.019 (0.013 - 0.025)	0.077 (0.055 - 0.099)	0.18 (0.13 - 0.24)	1.0[E] (0.44 - 1.6)
12–19	2	510	0.39	0.10 (0.082 - 0.13)	0.026 (0.022 - 0.030)	0.080 (0.065 - 0.095)	0.18[E] (0.10 - 0.27)	1.7[E] (0.90 - 2.4)
20–39	1	1151	1.13	0.086 (0.070 - 0.11)	0.020 (0.015 - 0.024)	0.076 (0.057 - 0.094)	0.15 (0.12 - 0.19)	0.75[E] (0.35 - 1.1)
20–39	2	359	0.28	0.18[E] (0.12 - 0.29)	0.027 (0.019 - 0.035)	0.13 (0.092 - 0.17)	0.37[E] (0.13 - 0.61)	F
40–59	1	1208	2.15	0.092 (0.073 - 0.12)	0.018 (0.012 - 0.024)	0.077 (0.054 - 0.099)	0.21 (0.16 - 0.26)	1.2 (0.91 - 1.5)
40–59	2	359	1.11	0.12 (0.089 - 0.17)	0.024 (0.016 - 0.031)	0.10[E] (0.054 - 0.15)	0.32 (0.20 - 0.43)	1.6[E] (0.46 - 2.7)
60–79	1	1076	0.93	0.083 (0.066 - 0.10)	0.019 (0.015 - 0.024)	0.067 (0.050 - 0.083)	0.16[E] (0.094 - 0.23)	0.75 (0.47 - 1.0)
60–79	2	291	0.69	0.11[E] (0.072 - 0.16)	0.021 (0.014 - 0.029)	0.086 (0.064 - 0.11)	F	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.3.3

cis-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1277	1.10	0.10 (0.086 - 0.13)	0.024 (0.018 - 0.029)	0.088 (0.068 - 0.11)	0.22^{E} (0.14 - 0.31)	1.2^{E} (0.39 - 2.1)
Males, 6–11	1	524	2.48	0.052 (0.039 - 0.070)	0.013^{E} (<LOD - 0.021)	0.046 (0.035 - 0.056)	0.092 (0.078 - 0.11)	F
Males, 6–11	2	260	0.77	0.071 (0.054 - 0.093)	0.019 (0.014 - 0.024)	0.055 (0.045 - 0.065)	0.11^{E} (0.034 - 0.19)	F
Males, 12–19	1	498	0.20	0.082 (0.062 - 0.11)	0.020 (0.017 - 0.024)	0.069 (0.051 - 0.087)	0.14^{E} (0.076 - 0.20)	0.97^{E} (0.40 - 1.5)
Males, 12–19	2	255	0.39	0.089 (0.071 - 0.11)	0.026 (0.022 - 0.030)	0.073 (0.059 - 0.088)	0.14^{E} (0.074 - 0.20)	0.95^{E} (0.27 - 1.6)
Males, 20–39	1	506	1.78	0.089 (0.069 - 0.11)	0.020 (0.014 - 0.026)	0.075 (0.054 - 0.096)	0.16^{E} (0.10 - 0.22)	F
Males, 20–39	2	168	0.60	0.11^{E} (0.073 - 0.16)	0.027^{E} (0.017 - 0.036)	0.11 (0.085 - 0.14)	F	x
Males, 40–59	1	569	1.76	0.10 (0.080 - 0.14)	0.021 (0.014 - 0.027)	0.081 (0.056 - 0.11)	0.23^{E} (0.14 - 0.33)	1.3^{E} (0.42 - 2.2)
Males, 40–59	2	194	2.06	0.12^{E} (0.084 - 0.18)	0.021^{E} (0.010 - 0.032)	0.10^{E} (0.035 - 0.17)	0.31^{E} (0.19 - 0.43)	x
Males, 60–79	1	539	0.56	0.091 (0.071 - 0.12)	0.026 (0.019 - 0.032)	0.076 (0.051 - 0.10)	0.18^{E} (0.11 - 0.24)	0.71 (0.50 - 0.93)
Males, 60–79	2	142	0.70	0.10^{E} (0.067 - 0.16)	0.025^{E} (0.016 - 0.033)	0.081^{E} (0.051 - 0.11)	0.19^{E} (0.069 - 0.31)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1276	0.63	0.15 (0.11 - 0.20)	0.025 (0.020 - 0.030)	0.099 (0.077 - 0.12)	0.36^{E} (0.20 - 0.52)	F
Females, 6–11	1	502	2.99	0.055 (0.045 - 0.068)	0.015 (0.012 - 0.017)	0.054 (0.039 - 0.069)	0.11 (0.088 - 0.14)	0.41^{E} (0.22 - 0.59)
Females, 6–11	2	254	1.57	0.068 (0.054 - 0.084)	0.016 (0.010 - 0.022)	0.057 (0.039 - 0.076)	0.11 (0.076 - 0.15)	F
Females, 12–19	1	472	1.48	0.10^{E} (0.070 - 0.15)	0.017^{E} (<LOD - 0.028)	0.086 (0.054 - 0.12)	0.22^{E} (0.13 - 0.30)	F
Females, 12–19	2	255	0.39	0.12 (0.086 - 0.18)	0.026 (0.017 - 0.035)	0.093 (0.073 - 0.11)	F	1.8^{E} (0.82 - 2.8)
Females, 20–39	1	645	0.62	0.084 (0.068 - 0.10)	0.020 (0.015 - 0.025)	0.078 (0.059 - 0.097)	0.15 (0.11 - 0.18)	0.68 (0.46 - 0.90)
Females, 20–39	2	191	0	0.30^{E} (0.15 - 0.61)	0.027^{E} (0.0088 - 0.045)	F	F	x
Females, 40–59	1	639	2.50	0.080 (0.063 - 0.10)	0.014^{E} (0.0070 - 0.021)	0.072^{E} (0.045 - 0.099)	0.19 (0.14 - 0.24)	0.79 (0.55 - 1.0)
Females, 40–59	2	165	0	0.12^{E} (0.078 - 0.19)	0.027^{E} (0.015 - 0.039)	0.099^{E} (0.042 - 0.16)	0.33^{E} (0.15 - 0.52)	x
Females, 60–79	1	537	1.30	0.076 (0.059 - 0.098)	0.017 (0.014 - 0.021)	0.061 (0.044 - 0.077)	0.14^{E} (0.064 - 0.22)	0.86^{E} (0.44 - 1.3)
Females, 60–79	2	149	0.67	0.11^{E} (0.068 - 0.18)	0.019^{E} (0.010 - 0.027)	F	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.5.3.4

cis-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5417	1.57	0.10 (0.087 - 0.12)	0.027 (0.024 - 0.031)	0.086 (0.072 - 0.099)	0.18 (0.13 - 0.22)	1.1 (0.84 - 1.3)
Total, 6–79	2	2024	0.74	0.12 (0.10 - 0.15)	0.029 (0.026 - 0.032)	0.088 (0.071 - 0.10)	0.23 (0.17 - 0.28)	F
Males, Total 6–79	1	2627	1.37	0.089 (0.074 - 0.11)	0.024 (0.021 - 0.026)	0.071 (0.059 - 0.083)	0.15 (0.11 - 0.20)	0.99 (0.66 - 1.3)
Males, Total 6–79	2	1016	0.89	0.087 (0.075 - 0.10)	0.026 (0.023 - 0.029)	0.069 (0.054 - 0.084)	0.15 (0.12 - 0.18)	0.96^{E} (0.42 - 1.5)
Females, Total 6–79	1	2790	1.76	0.12 (0.10 - 0.14)	0.033 (0.028 - 0.038)	0.099 (0.085 - 0.11)	0.20 (0.13 - 0.26)	1.2 (0.96 - 1.4)
Females, Total 6–79	2	1008	0.60	0.17 (0.13 - 0.22)	0.034 (0.029 - 0.040)	0.11 (0.079 - 0.14)	0.33^{E} (0.19 - 0.48)	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.3.5

cis-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2543	0.87	0.12 (0.10 - 0.15)	0.029 (0.026 - 0.032)	0.088 (0.071 - 0.10)	0.23 (0.17 - 0.28)	F
3–5[b]	1							
3–5	2	519	1.35	0.11 (0.084 - 0.16)	0.031 (0.022 - 0.039)	0.091 (0.064 - 0.12)	0.18^{E} (0.10 - 0.26)	F
6–11	1	1023	2.74	0.083 (0.070 - 0.098)	0.028 (0.022 - 0.033)	0.071 (0.063 - 0.079)	0.13 (0.094 - 0.17)	0.58^{E} (0.21 - 0.95)
6–11	2	512	1.17	0.080 (0.068 - 0.094)	0.027 (0.023 - 0.031)	0.059 (0.052 - 0.066)	0.13 (0.098 - 0.16)	0.71^{E} (<LOD - 1.2)
12–19	1	968	0.83	0.079 (0.062 - 0.10)	0.022 (0.020 - 0.024)	0.061 (0.043 - 0.080)	0.14 (0.10 - 0.18)	0.98^{E} (0.55 - 1.4)
12–19	2	508	0.39	0.079 (0.063 - 0.10)	0.024 (0.020 - 0.027)	0.061 (0.047 - 0.074)	0.12^{E} (0.055 - 0.19)	0.88^{E} (0.53 - 1.2)
20–39	1	1147	1.13	0.096 (0.080 - 0.12)	0.026 (0.021 - 0.031)	0.084 (0.069 - 0.099)	0.16 (0.13 - 0.20)	0.82^{E} (0.40 - 1.2)
20–39	2	357	0.28	0.16^{E} (0.10 - 0.23)	0.029 (0.025 - 0.034)	0.10 (0.072 - 0.13)	0.26^{E} (0.084 - 0.44)	F
40–59	1	1203	2.16	0.12 (0.097 - 0.14)	0.029 (0.023 - 0.035)	0.097 (0.079 - 0.11)	0.23 (0.15 - 0.31)	1.2 (0.97 - 1.5)
40–59	2	357	1.12	0.12 (0.10 - 0.15)	0.032 (0.023 - 0.041)	0.084^{E} (0.046 - 0.12)	0.23 (0.18 - 0.29)	1.3^{E} (0.50 - 2.1)
60–79	1	1076	0.93	0.12 (0.093 - 0.14)	0.034 (0.031 - 0.037)	0.093 (0.073 - 0.11)	0.20^{E} (0.12 - 0.28)	1.2^{E} (0.61 - 1.7)
60–79	2	290	0.69	0.13^{E} (0.083 - 0.19)	0.030 (0.020 - 0.041)	0.096 (0.067 - 0.12)	0.23^{E} (<LOD - 0.37)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.3.6

cis-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1273	1.10	0.088 (0.075 - 0.10)	0.026 (0.023 - 0.029)	0.069 (0.054 - 0.084)	0.15 (0.12 - 0.18)	0.96^{E} (0.44 - 1.5)
Males, 6–11	1	522	2.49	0.079 (0.065 - 0.095)	0.027 (<LOD - 0.032)	0.068 (0.062 - 0.074)	0.11 (0.078 - 0.15)	F
Males, 6–11	2	259	0.77	0.081 (0.064 - 0.10)	0.027 (0.020 - 0.034)	0.059 (0.052 - 0.066)	0.12^{E} (0.057 - 0.19)	F
Males, 12–19	1	497	0.20	0.070 (0.053 - 0.092)	0.022 (0.019 - 0.024)	0.052 (0.036 - 0.069)	0.12^{E} (0.075 - 0.17)	0.71^{E} (0.25 - 1.2)
Males, 12–19	2	254	0.39	0.063 (0.050 - 0.079)	0.020 (0.017 - 0.023)	0.051 (0.041 - 0.061)	0.092^{E} (0.054 - 0.13)	0.76^{E} (0.25 - 1.3)
Males, 20–39	1	504	1.79	0.082 (0.065 - 0.10)	0.022 (0.019 - 0.026)	0.067 (0.054 - 0.081)	0.14 (0.090 - 0.18)	F
Males, 20–39	2	167	0.60	0.077 (0.055 - 0.11)	0.027 (0.021 - 0.033)	0.068 (0.045 - 0.090)	0.13 (0.098 - 0.17)	x
Males, 40–59	1	565	1.77	0.10 (0.082 - 0.13)	0.024 (0.019 - 0.029)	0.081 (0.061 - 0.10)	0.21^{E} (0.12 - 0.29)	1.3^{E} (0.60 - 2.0)
Males, 40–59	2	194	2.06	0.11 (0.083 - 0.13)	0.027 (0.018 - 0.035)	0.076^{E} (0.040 - 0.11)	0.20 (0.15 - 0.25)	x
Males, 60–79	1	539	0.56	0.096 (0.080 - 0.11)	0.029 (0.023 - 0.035)	0.074 (0.054 - 0.094)	0.16 (0.11 - 0.22)	0.67^{E} (0.31 - 1.0)
Males, 60–79	2	142	0.70	0.098^{E} (0.067 - 0.14)	0.024^{E} (0.0092 - 0.039)	0.082^{E} (0.052 - 0.11)	0.16^{E} (0.086 - 0.24)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1270	0.63	0.17 (0.13 - 0.22)	0.035 (0.029 - 0.040)	0.11 (0.080 - 0.14)	0.33^{E} (0.19 - 0.46)	F
Females, 6–11	1	501	2.99	0.087 (0.071 - 0.11)	0.028 (0.021 - 0.035)	0.077 (0.058 - 0.096)	0.15 (0.11 - 0.19)	0.54 (0.34 - 0.73)
Females, 6–11	2	253	1.58	0.080 (0.064 - 0.10)	0.025 (0.019 - 0.031)	0.064 (0.050 - 0.078)	0.13^{E} (0.083 - 0.18)	F
Females, 12–19	1	471	1.49	0.091 (0.071 - 0.12)	0.023 (<LOD - 0.028)	0.073 (0.052 - 0.095)	0.17 (0.12 - 0.21)	1.6^{E} (0.47 - 2.8)
Females, 12–19	2	254	0.39	0.10 (0.076 - 0.13)	0.030 (0.023 - 0.037)	0.073 (0.059 - 0.087)	F	1.1^{E} (0.41 - 1.8)
Females, 20–39	1	643	0.62	0.11 (0.093 - 0.14)	0.032 (0.025 - 0.039)	0.099 (0.080 - 0.12)	0.18 (0.13 - 0.23)	0.78^{E} (0.41 - 1.2)
Females, 20–39	2	190	0	0.31^{E} (0.16 - 0.59)	0.040^{E} (0.020 - 0.061)	F	F	x
Females, 40–59	1	638	2.51	0.13 (0.11 - 0.16)	0.040 (0.034 - 0.045)	0.10 (0.087 - 0.12)	0.24^{E} (0.13 - 0.36)	1.2 (0.98 - 1.4)
Females, 40–59	2	163	0	0.14 (0.11 - 0.20)	0.042 (0.027 - 0.057)	0.11^{E} (0.050 - 0.17)	0.26^{E} (0.12 - 0.40)	x
Females, 60–79	1	537	1.30	0.14 (0.10 - 0.18)	0.036 (0.027 - 0.045)	0.11 (0.079 - 0.14)	0.24^{E} (0.11 - 0.38)	1.5^{E} (0.81 - 2.2)
Females, 60–79	2	148	0.68	0.16^{E} (0.087 - 0.28)	0.034^{E} (0.021 - 0.046)	0.11^{E} (0.059 - 0.17)	0.30^{E} (<LOD - 0.48)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.5.4 *trans*-3-(2,2-Dichlorovinyl)-2,2-Dimethylcyclopropane Carboxylic Acid (*trans*-DCCA)

Table 14.5.4.1

trans-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5457	0.40	0.20 (0.17 - 0.24)	0.040 (0.032 - 0.049)	0.17 (0.14 - 0.20)	0.43 (0.33 - 0.53)	2.5 (1.9 - 3.1)
Total, 6–79	2	2037	0.39	0.29 (0.23 - 0.37)	0.051 (0.043 - 0.059)	0.22 (0.17 - 0.26)	0.68 (0.45 - 0.91)	6.8[E] (1.9 - 12)
Males, Total 6–79	1	2650	0.30	0.22 (0.18 - 0.26)	0.046 (0.036 - 0.055)	0.18 (0.15 - 0.20)	0.44 (0.31 - 0.57)	2.8[E] (1.4 - 4.2)
Males, Total 6–79	2	1021	0.39	0.25 (0.20 - 0.31)	0.048 (0.035 - 0.061)	0.21 (0.17 - 0.25)	0.55[E] (0.30 - 0.81)	F
Females, Total 6–79	1	2807	0.50	0.19 (0.16 - 0.22)	0.036 (0.028 - 0.043)	0.16 (0.13 - 0.20)	0.41 (0.32 - 0.51)	2.1 (1.5 - 2.7)
Females, Total 6–79	2	1016	0.39	0.34 (0.25 - 0.47)	0.052 (0.039 - 0.065)	0.22 (0.16 - 0.29)	0.77[E] (0.33 - 1.2)	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.4.2

trans-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2558	0.35	0.29 (0.23 - 0.37)	0.051 (0.043 - 0.059)	0.22 (0.17 - 0.26)	0.67 (0.45 - 0.90)	6.8[E] (2.1 - 11)
3–5[b]	1							
3–5	2	521	0.19	0.22 (0.16 - 0.31)	0.055 (0.038 - 0.071)	0.19 (0.13 - 0.25)	0.40[E] (0.22 - 0.59)	F
6–11	1	1027	0.29	0.17 (0.15 - 0.21)	0.041[E] (0.025 - 0.057)	0.15 (0.12 - 0.18)	0.34 (0.27 - 0.41)	1.4 (1.1 - 1.8)
6–11	2	516	0.78	0.21 (0.18 - 0.25)	0.048 (0.037 - 0.059)	0.17 (0.15 - 0.19)	0.37 (0.24 - 0.50)	F
12–19	1	978	0.10	0.24 (0.18 - 0.33)	0.048[E] (0.030 - 0.066)	0.20 (0.16 - 0.24)	0.49[E] (0.27 - 0.70)	3.8[E] (2.0 - 5.6)
12–19	2	511	0	0.27 (0.21 - 0.34)	0.057 (0.048 - 0.067)	0.20 (0.16 - 0.25)	0.50[E] (0.23 - 0.77)	4.8[E] (2.1 - 7.5)
20–39	1	1158	0.60	0.20 (0.16 - 0.24)	0.042 (0.031 - 0.053)	0.17 (0.14 - 0.21)	0.40 (0.30 - 0.49)	2.0[E] (1.1 - 2.8)
20–39	2	359	0	0.41[E] (0.25 - 0.66)	0.061 (0.040 - 0.082)	0.28[E] (0.12 - 0.43)	0.79[E] (0.35 - 1.2)	F
40–59	1	1216	0.58	0.21 (0.17 - 0.26)	0.037 (0.029 - 0.044)	0.18 (0.13 - 0.22)	0.51 (0.33 - 0.69)	3.2[E] (1.9 - 4.5)
40–59	2	360	0.56	0.27 (0.20 - 0.35)	0.041[E] (0.022 - 0.060)	0.22 (0.15 - 0.30)	0.69[E] (0.41 - 0.96)	F
60–79	1	1078	0.37	0.18 (0.15 - 0.22)	0.040 (0.032 - 0.047)	0.15 (0.12 - 0.18)	0.35[E] (0.21 - 0.49)	1.9[E] (1.1 - 2.6)
60–79	2	291	0.69	0.23[E] (0.14 - 0.39)	0.041[E] (0.026 - 0.056)	0.17[E] (0.082 - 0.25)	F	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.4.3

trans-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1279	0.31	0.25 (0.20 - 0.31)	0.048 (0.036 - 0.060)	0.21 (0.17 - 0.25)	0.55[E] (0.31 - 0.80)	F
Males, 6–11	1	524	0.19	0.17 (0.13 - 0.22)	0.040[E] (0.017 - 0.064)	0.14 (0.11 - 0.17)	0.30 (0.24 - 0.36)	1.5[E] (0.81 - 2.1)
Males, 6–11	2	262	0.76	0.21 (0.16 - 0.28)	0.047[E] (0.028 - 0.066)	0.18 (0.15 - 0.22)	0.39[E] (0.13 - 0.65)	F
Males, 12–19	1	501	0	0.22 (0.17 - 0.30)	0.049 (0.033 - 0.064)	0.19 (0.15 - 0.22)	0.43[E] (0.24 - 0.62)	2.4[E] (0.75 - 4.0)
Males, 12–19	2	255	0	0.24 (0.18 - 0.30)	0.058 (0.048 - 0.067)	0.18 (0.13 - 0.23)	0.42[E] (0.26 - 0.59)	F
Males, 20–39	1	510	0.78	0.21 (0.16 - 0.26)	0.045 (0.033 - 0.057)	0.17 (0.13 - 0.21)	0.41[E] (0.25 - 0.57)	F
Males, 20–39	2	168	0	0.27[E] (0.18 - 0.39)	0.060[E] (0.029 - 0.091)	0.25[E] (0.15 - 0.36)	0.53[E] (0.18 - 0.88)	x
Males, 40–59	1	576	0.35	0.25 (0.19 - 0.33)	0.043 (0.031 - 0.056)	0.20 (0.15 - 0.25)	0.60[E] (0.35 - 0.84)	F
Males, 40–59	2	194	1.03	0.27[E] (0.18 - 0.40)	0.038[E] (0.016 - 0.060)	0.21[E] (0.085 - 0.34)	0.76[E] (0.37 - 1.1)	x
Males, 60–79	1	539	0.19	0.20 (0.16 - 0.25)	0.052 (0.044 - 0.060)	0.17 (0.13 - 0.21)	0.39 (0.26 - 0.52)	1.7[E] (1.1 - 2.3)
Males, 60–79	2	142	0	0.22[E] (0.13 - 0.38)	0.041[E] (0.024 - 0.059)	0.17[E] (0.074 - 0.26)	F	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1279	0.39	0.34 (0.24 - 0.46)	0.052 (0.040 - 0.064)	0.22 (0.16 - 0.28)	0.74[E] (0.33 - 1.1)	F
Females, 6–11	1	503	0.40	0.18 (0.15 - 0.22)	0.042 (0.029 - 0.056)	0.16 (0.12 - 0.21)	0.38 (0.28 - 0.49)	1.4 (0.98 - 1.9)
Females, 6–11	2	254	0.79	0.21 (0.16 - 0.26)	0.048 (0.036 - 0.060)	0.16 (0.12 - 0.20)	0.37[E] (0.21 - 0.53)	F
Females, 12–19	1	477	0.21	0.27 (0.19 - 0.37)	0.045[E] (0.023 - 0.067)	0.21 (0.16 - 0.26)	0.66[E] (0.36 - 0.96)	F
Females, 12–19	2	256	0	0.31 (0.22 - 0.44)	0.057[E] (0.032 - 0.083)	0.25 (0.17 - 0.32)	F	5.9[E] (2.9 - 9.0)
Females, 20–39	1	648	0.46	0.19 (0.16 - 0.23)	0.037 (0.025 - 0.050)	0.17 (0.13 - 0.22)	0.37 (0.29 - 0.46)	1.7[E] (1.1 - 2.4)
Females, 20–39	2	191	0	F	0.065[E] (0.035 - 0.095)	F	F	x
Females, 40–59	1	640	0.78	0.18 (0.15 - 0.23)	0.033 (0.025 - 0.041)	0.16[E] (0.099 - 0.22)	0.45[E] (0.27 - 0.63)	2.2 (1.4 - 2.9)
Females, 40–59	2	166	0	0.27[E] (0.17 - 0.42)	0.047[E] (0.018 - 0.077)	0.22[E] (0.13 - 0.32)	0.60[E] (0.19 - 1.0)	x
Females, 60–79	1	539	0.56	0.16 (0.13 - 0.21)	0.034 (0.026 - 0.042)	0.12 (0.090 - 0.16)	0.30[E] (0.11 - 0.50)	2.0[E] (0.92 - 3.1)
Females, 60–79	2	149	1.34	0.24[E] (0.13 - 0.45)	0.039[E] (0.023 - 0.056)	F	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.5.4.4

trans-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5443	0.40	0.25 (0.21 - 0.29)	0.062 (0.057 - 0.067)	0.19 (0.16 - 0.22)	0.46 (0.35 - 0.56)	3.0 (2.3 - 3.7)
Total, 6–79	2	2028	0.39	0.28 (0.23 - 0.35)	0.062 (0.054 - 0.069)	0.20 (0.15 - 0.24)	0.56 (0.42 - 0.70)	F
Males, Total 6–79	1	2641	0.30	0.22 (0.18 - 0.26)	0.056 (0.049 - 0.063)	0.17 (0.14 - 0.19)	0.39 (0.28 - 0.50)	2.6^{E} (1.7 - 3.6)
Males, Total 6–79	2	1018	0.39	0.21 (0.17 - 0.25)	0.054 (0.044 - 0.064)	0.17 (0.13 - 0.21)	0.36 (0.25 - 0.47)	F
Females, Total 6–79	1	2802	0.50	0.28 (0.24 - 0.32)	0.068 (0.060 - 0.076)	0.22 (0.17 - 0.26)	0.51 (0.37 - 0.65)	3.3 (2.8 - 3.9)
Females, Total 6–79	2	1010	0.40	0.38 (0.28 - 0.52)	0.070 (0.058 - 0.083)	0.24 (0.18 - 0.31)	0.93^{E} (0.52 - 1.3)	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.4.5

trans-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2548	0.35	0.28 (0.23 - 0.35)	0.063 (0.055 - 0.070)	0.20 (0.15 - 0.24)	0.57 (0.43 - 0.71)	F
3–5[b]	1							
3–5	2	520	0.19	0.39 (0.27 - 0.55)	0.097 (0.063 - 0.13)	0.32 (0.22 - 0.42)	0.78^{E} (0.48 - 1.1)	F
6–11	1	1024	0.29	0.27 (0.24 - 0.31)	0.086 (0.078 - 0.095)	0.21 (0.18 - 0.24)	0.46 (0.37 - 0.54)	2.4^{E} (1.3 - 3.6)
6–11	2	514	0.78	0.24 (0.21 - 0.29)	0.077 (0.068 - 0.087)	0.18 (0.16 - 0.21)	0.43 (0.30 - 0.55)	F
12–19	1	976	0.10	0.21 (0.17 - 0.27)	0.056 (0.047 - 0.065)	0.15 (0.11 - 0.20)	0.42^{E} (0.25 - 0.60)	2.4^{E} (1.2 - 3.5)
12–19	2	509	0	0.21 (0.16 - 0.26)	0.057 (0.049 - 0.065)	0.16 (0.12 - 0.19)	0.32^{E} (0.092 - 0.54)	2.4^{E} (1.3 - 3.5)
20–39	1	1154	0.61	0.22 (0.19 - 0.26)	0.058 (0.050 - 0.067)	0.17 (0.14 - 0.21)	0.40 (0.31 - 0.49)	2.3^{E} (1.4 - 3.3)
20–39	2	357	0	0.35^{E} (0.23 - 0.54)	0.059 (0.039 - 0.079)	0.22^{E} (0.13 - 0.30)	0.58^{E} (0.28 - 0.89)	F
40–59	1	1211	0.58	0.27 (0.23 - 0.33)	0.063 (0.057 - 0.069)	0.20 (0.17 - 0.23)	0.50^{E} (0.30 - 0.70)	3.6 (2.9 - 4.4)
40–59	2	358	0.56	0.27 (0.23 - 0.32)	0.065 (0.051 - 0.079)	0.20^{E} (0.12 - 0.27)	0.60 (0.43 - 0.76)	F
60–79	1	1078	0.37	0.25 (0.21 - 0.31)	0.066 (0.060 - 0.072)	0.20 (0.16 - 0.25)	0.48^{E} (0.29 - 0.66)	2.9^{E} (1.7 - 4.2)
60–79	2	290	0.69	0.27^{E} (0.16 - 0.45)	0.052 (0.036 - 0.069)	0.19^{E} (0.10 - 0.27)	F	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.4.6

trans-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1275	0.31	0.21 (0.18 - 0.25)	0.055 (0.045 - 0.065)	0.17 (0.13 - 0.21)	0.38 (0.27 - 0.49)	F
Males, 6–11	1	522	0.19	0.26 (0.22 - 0.30)	0.083 (0.073 - 0.092)	0.20 (0.17 - 0.23)	0.39 (0.30 - 0.49)	2.5^{E} (0.76 - 4.3)
Males, 6–11	2	261	0.77	0.24 (0.20 - 0.30)	0.082 (0.065 - 0.098)	0.19 (0.16 - 0.21)	0.46^{E} (0.25 - 0.66)	F
Males, 12–19	1	500	0	0.19 (0.14 - 0.25)	0.054 (0.045 - 0.063)	0.15 (0.11 - 0.19)	0.38^{E} (0.19 - 0.58)	1.8^{E} (0.90 - 2.7)
Males, 12–19	2	254	0	0.17 (0.13 - 0.21)	0.054 (0.046 - 0.063)	0.13 (0.097 - 0.16)	0.24^{E} (0.13 - 0.34)	1.8^{E} (<LOD - 3.0)
Males, 20–39	1	508	0.79	0.19 (0.16 - 0.24)	0.053 (0.039 - 0.067)	0.14 (0.11 - 0.17)	0.32 (0.22 - 0.43)	2.5^{E} (<LOD - 4.3)
Males, 20–39	2	167	0	0.19 (0.14 - 0.25)	0.059 (0.042 - 0.076)	0.17 (0.12 - 0.22)	0.32 (0.23 - 0.42)	x
Males, 40–59	1	572	0.35	0.25 (0.19 - 0.31)	0.056 (0.044 - 0.069)	0.19 (0.16 - 0.22)	0.49^{E} (0.29 - 0.69)	3.9^{E} (2.0 - 5.8)
Males, 40–59	2	194	1.03	0.23 (0.18 - 0.29)	0.050^{E} (0.031 - 0.069)	0.15^{E} (0.050 - 0.24)	0.51^{E} (0.28 - 0.73)	x
Males, 60–79	1	539	0.19	0.21 (0.18 - 0.25)	0.059 (0.053 - 0.065)	0.16 (0.13 - 0.19)	0.37 (0.24 - 0.51)	1.6^{E} (0.95 - 2.3)
Males, 60–79	2	142	0	0.21^{E} (0.14 - 0.33)	0.039^{E} (0.017 - 0.060)	0.19^{E} (0.11 - 0.27)	0.38^{E} (0.15 - 0.61)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1273	0.39	0.38 (0.29 - 0.51)	0.071 (0.058 - 0.083)	0.24 (0.18 - 0.31)	0.93^{E} (0.53 - 1.3)	F
Females, 6–11	1	502	0.40	0.29 (0.24 - 0.34)	0.087 (0.075 - 0.098)	0.22 (0.17 - 0.28)	0.51 (0.36 - 0.67)	2.1^{E} (0.66 - 3.4)
Females, 6–11	2	253	0.79	0.24 (0.19 - 0.31)	0.077 (0.067 - 0.086)	0.18 (0.13 - 0.22)	0.43^{E} (0.26 - 0.59)	F
Females, 12–19	1	476	0.21	0.24 (0.19 - 0.30)	0.061 (0.052 - 0.071)	0.17 (0.12 - 0.22)	0.49^{E} (0.29 - 0.69)	F
Females, 12–19	2	255	0	0.26 (0.19 - 0.34)	0.064 (0.047 - 0.081)	0.19 (0.14 - 0.24)	F	3.1^{E} (0.95 - 5.2)
Females, 20–39	1	646	0.46	0.26 (0.21 - 0.31)	0.063 (0.052 - 0.075)	0.20 (0.14 - 0.27)	0.47 (0.35 - 0.58)	2.3^{E} (1.1 - 3.5)
Females, 20–39	2	190	0	0.64^{E} (0.31 - 1.3)	0.067^{E} (0.038 - 0.096)	F	F	x
Females, 40–59	1	639	0.78	0.30 (0.26 - 0.36)	0.077 (0.061 - 0.092)	0.22 (0.16 - 0.28)	0.53^{E} (0.27 - 0.80)	3.6 (3.0 - 4.1)
Females, 40–59	2	164	0	0.32 (0.24 - 0.44)	0.078^{E} (0.050 - 0.11)	0.24^{E} (0.14 - 0.33)	F	x
Females, 60–79	1	539	0.56	0.30 (0.22 - 0.39)	0.073 (0.061 - 0.085)	0.25 (0.18 - 0.31)	0.57^{E} (0.34 - 0.80)	3.5^{E} (1.6 - 5.4)
Females, 60–79	2	148	1.35	F	0.067 (0.051 - 0.084)	F	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

14.5.5 3-Phenoxybenzoic Acid (3-PBA)

Table 14.5.5.1

3-Phenoxybenzoic acid (3-PBA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5450	0.61	0.25 (0.21 - 0.31)	0.050 (0.038 - 0.063)	0.22 (0.17 - 0.27)	0.55 (0.42 - 0.68)	2.9 (2.1 - 3.8)
Total, 6–79	2	1994	0	0.43 (0.35 - 0.54)	0.079 (0.066 - 0.091)	0.36 (0.29 - 0.43)	0.99 (0.71 - 1.3)	5.8[E] (2.0 - 9.7)
Males, Total 6–79	1	2646	0.42	0.27 (0.22 - 0.33)	0.055 (0.044 - 0.065)	0.23 (0.18 - 0.28)	0.56 (0.43 - 0.70)	3.3 (2.2 - 4.4)
Males, Total 6–79	2	997	0	0.37 (0.30 - 0.46)	0.073 (0.053 - 0.093)	0.33 (0.27 - 0.39)	0.87 (0.66 - 1.1)	F
Females, Total 6–79	1	2804	0.78	0.24 (0.19 - 0.30)	0.045 (0.031 - 0.059)	0.22 (0.17 - 0.27)	0.55 (0.40 - 0.69)	2.6 (1.9 - 3.3)
Females, Total 6–79	2	997	0	0.50 (0.37 - 0.67)	0.084 (0.068 - 0.10)	0.38 (0.26 - 0.50)	1.1[E] (0.64 - 1.6)	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.5.2

3-Phenoxybenzoic acid (3-PBA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2516	0.04	0.43 (0.34 - 0.53)	0.079 (0.066 - 0.091)	0.36 (0.29 - 0.43)	0.94 (0.68 - 1.2)	5.9[E] (2.2 - 9.5)
3–5[b]	1							
3–5	2	522	0.19	0.32 (0.23 - 0.45)	0.078 (0.057 - 0.099)	0.27 (0.21 - 0.33)	0.60 (0.41 - 0.79)	F
6–11	1	1025	0.68	0.21 (0.16 - 0.28)	0.047 (0.034 - 0.060)	0.19 (0.14 - 0.24)	0.42 (0.33 - 0.51)	1.7[E] (0.51 - 2.9)
6–11	2	515	0	0.30 (0.25 - 0.35)	0.079 (0.063 - 0.095)	0.24 (0.19 - 0.30)	0.54 (0.38 - 0.70)	F
12–19	1	977	0.20	0.28 (0.21 - 0.38)	0.059[E] (0.030 - 0.088)	0.25 (0.18 - 0.32)	0.61 (0.43 - 0.80)	3.2[E] (2.0 - 4.5)
12–19	2	509	0	0.36 (0.28 - 0.45)	0.096 (0.085 - 0.11)	0.27 (0.20 - 0.35)	0.64[E] (0.39 - 0.89)	5.6[E] (2.8 - 8.3)
20–39	1	1159	0.35	0.25 (0.20 - 0.32)	0.051 (0.036 - 0.067)	0.21 (0.16 - 0.26)	0.50 (0.38 - 0.62)	2.5[E] (1.6 - 3.5)
20–39	2	345	0	0.61[E] (0.41 - 0.92)	0.094[E] (0.056 - 0.13)	0.48[E] (0.28 - 0.67)	1.2[E] (0.70 - 1.7)	F
40–59	1	1216	1.07	0.27 (0.21 - 0.34)	0.046 (0.032 - 0.060)	0.25 (0.18 - 0.32)	0.65 (0.48 - 0.82)	3.5[E] (2.0 - 5.0)
40–59	2	346	0	0.40 (0.29 - 0.55)	0.064[E] (0.041 - 0.088)	0.36 (0.24 - 0.48)	0.97 (0.63 - 1.3)	4.2[E] (2.0 - 6.4)
60–79	1	1073	0.65	0.24 (0.20 - 0.29)	0.051 (0.041 - 0.062)	0.21 (0.17 - 0.25)	0.52 (0.34 - 0.70)	2.2 (1.5 - 2.8)
60–79	2	279	0	0.36[E] (0.24 - 0.55)	0.074 (0.055 - 0.093)	0.27[E] (0.14 - 0.41)	F	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.5.3

3-Phenoxybenzoic acid (3-PBA) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1256	0.08	0.37 (0.30 - 0.46)	0.073 (0.053 - 0.092)	0.33 (0.27 - 0.39)	0.87 (0.66 - 1.1)	F
Males, 6–11	1	524	0.38	0.20^{E} (0.14 - 0.30)	0.047^{E} (0.022 - 0.071)	0.17 (0.12 - 0.23)	0.38 (0.27 - 0.49)	F
Males, 6–11	2	262	0	0.29 (0.23 - 0.38)	0.089 (0.059 - 0.12)	0.25 (0.19 - 0.31)	0.52 (0.34 - 0.70)	F
Males, 12–19	1	501	0	0.26 (0.20 - 0.35)	0.065^{E} (0.038 - 0.092)	0.23 (0.16 - 0.30)	0.55^{E} (0.31 - 0.79)	2.5^{E} (1.4 - 3.5)
Males, 12–19	2	253	0	0.31 (0.24 - 0.41)	0.10 (0.083 - 0.12)	0.23 (0.16 - 0.30)	0.58^{E} (0.32 - 0.84)	F
Males, 20–39	1	511	0.39	0.26 (0.20 - 0.34)	0.052^{E} (0.032 - 0.072)	0.21 (0.16 - 0.27)	0.52 (0.38 - 0.66)	F
Males, 20–39	2	161	0	0.41 (0.28 - 0.58)	F	0.42^{E} (0.16 - 0.69)	0.89 (0.59 - 1.2)	x
Males, 40–59	1	575	0.70	0.30 (0.23 - 0.40)	0.055 (0.043 - 0.067)	0.27 (0.20 - 0.35)	0.72^{E} (0.40 - 1.0)	4.1^{E} (1.5 - 6.6)
Males, 40–59	2	184	0	0.41^{E} (0.27 - 0.62)	0.061^{E} (0.024 - 0.098)	0.35^{E} (0.19 - 0.51)	F	x
Males, 60–79	1	535	0.56	0.26 (0.21 - 0.32)	0.058 (0.044 - 0.072)	0.23 (0.17 - 0.29)	0.61 (0.41 - 0.81)	2.2 (1.6 - 2.9)
Males, 60–79	2	137	0	0.34^{E} (0.21 - 0.55)	0.075 (0.060 - 0.091)	0.23^{E} (0.084 - 0.37)	F	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1260	0	0.49 (0.37 - 0.65)	0.084 (0.069 - 0.10)	0.38 (0.27 - 0.48)	1.1^{E} (0.65 - 1.6)	F
Females, 6–11	1	501	1.00	0.22 (0.17 - 0.29)	0.048 (0.036 - 0.060)	0.21 (0.16 - 0.27)	0.45 (0.33 - 0.57)	1.7^{E} (0.82 - 2.7)
Females, 6–11	2	253	0	0.30 (0.23 - 0.39)	0.061^{E} (0.027 - 0.096)	0.23^{E} (0.13 - 0.33)	0.60^{E} (0.34 - 0.86)	F
Females, 12–19	1	476	0.42	0.31^{E} (0.20 - 0.47)	0.056^{E} (0.020 - 0.093)	0.28^{E} (0.14 - 0.41)	0.66^{E} (0.39 - 0.94)	4.3^{E} (2.7 - 5.8)
Females, 12–19	2	256	0	0.41 (0.30 - 0.55)	0.094^{E} (0.054 - 0.13)	0.34 (0.24 - 0.44)	0.81^{E} (0.31 - 1.3)	6.0 (3.9 - 8.1)
Females, 20–39	1	648	0.31	0.24 (0.18 - 0.31)	0.051 (0.034 - 0.068)	0.22 (0.16 - 0.27)	0.49 (0.34 - 0.64)	2.6 (1.8 - 3.3)
Females, 20–39	2	184	0	0.91^{E} (0.47 - 1.8)	0.11^{E} (0.067 - 0.16)	F	F	x
Females, 40–59	1	641	1.40	0.24 (0.18 - 0.31)	0.039^{E} (0.024 - 0.053)	0.23 (0.16 - 0.31)	0.62 (0.49 - 0.76)	2.4^{E} (1.4 - 3.4)
Females, 40–59	2	162	0	0.39^{E} (0.25 - 0.61)	0.072^{E} (0.031 - 0.11)	0.37^{E} (0.19 - 0.54)	0.84^{E} (0.39 - 1.3)	x
Females, 60–79	1	538	0.74	0.22 (0.18 - 0.27)	0.045 (0.035 - 0.056)	0.19 (0.14 - 0.24)	0.48 (0.34 - 0.63)	2.1^{E} (1.2 - 3.1)
Females, 60–79	2	142	0	0.39^{E} (0.24 - 0.63)	0.066^{E} (0.027 - 0.10)	F	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 14.5.5.4

3-Phenoxybenzoic acid (3-PBA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–79 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–79	1	5436	0.61	0.31 (0.25 - 0.37)	0.078 (0.063 - 0.092)	0.26 (0.21 - 0.31)	0.58 (0.44 - 0.72)	2.8 (2.3 - 3.4)
Total, 6–79	2	1985	0	0.42 (0.34 - 0.51)	0.10 (0.091 - 0.11)	0.33 (0.26 - 0.39)	0.77 (0.57 - 0.96)	F
Males, Total 6–79	1	2637	0.42	0.27 (0.22 - 0.32)	0.072 (0.065 - 0.079)	0.22 (0.17 - 0.27)	0.49 (0.38 - 0.61)	2.5 (1.9 - 3.1)
Males, Total 6–79	2	994	0	0.31 (0.26 - 0.37)	0.088 (0.071 - 0.10)	0.26 (0.21 - 0.32)	0.52 (0.39 - 0.66)	F
Females, Total 6–79	1	2799	0.79	0.36 (0.29 - 0.44)	0.096 (0.080 - 0.11)	0.30 (0.25 - 0.36)	0.67 (0.47 - 0.86)	3.2 (2.5 - 3.9)
Females, Total 6–79	2	991	0	0.56 (0.43 - 0.73)	0.12 (0.10 - 0.14)	0.41 (0.30 - 0.51)	1.0[E] (0.56 - 1.4)	F

a For the purpose of total population comparisons, only values from participants aged 6–79 years were included as participants under the age of 6 years were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.5.5

3-Phenoxybenzoic acid (3-PBA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2506	0.04	0.42 (0.34 - 0.51)	0.10 (0.092 - 0.11)	0.33 (0.26 - 0.39)	0.78 (0.59 - 0.97)	F
3–5[b]	1							
3–5	2	521	0.19	0.56 (0.40 - 0.79)	0.15 (0.10 - 0.19)	0.46 (0.35 - 0.57)	0.92 (0.59 - 1.2)	F
6–11	1	1022	0.68	0.32 (0.26 - 0.40)	0.098 (0.080 - 0.12)	0.27 (0.22 - 0.33)	0.56 (0.42 - 0.71)	3.0[E] (1.4 - 4.6)
6–11	2	513	0	0.34 (0.29 - 0.41)	0.12 (0.11 - 0.14)	0.26 (0.18 - 0.34)	0.56 (0.36 - 0.76)	2.7[E] (1.1 - 4.2)
12–19	1	975	0.21	0.25 (0.19 - 0.32)	0.067 (0.052 - 0.082)	0.19 (0.14 - 0.25)	0.45 (0.33 - 0.57)	2.9[E] (1.7 - 4.0)
12–19	2	507	0	0.27 (0.22 - 0.34)	0.081 (0.070 - 0.093)	0.21 (0.15 - 0.27)	0.42[E] (0.14 - 0.69)	2.6 (2.1 - 3.2)
20–39	1	1155	0.35	0.28 (0.22 - 0.35)	0.073 (0.052 - 0.094)	0.23 (0.17 - 0.29)	0.51 (0.38 - 0.63)	2.4 (1.5 - 3.2)
20–39	2	343	0	0.52[E] (0.35 - 0.75)	0.11 (0.082 - 0.13)	0.35[E] (0.21 - 0.49)	0.87[E] (0.48 - 1.3)	F
40–59	1	1211	1.07	0.35 (0.28 - 0.43)	0.084 (0.068 - 0.10)	0.30 (0.24 - 0.35)	0.71 (0.50 - 0.93)	2.9 (2.2 - 3.7)
40–59	2	344	0	0.41 (0.33 - 0.51)	0.11 (0.093 - 0.13)	0.35 (0.25 - 0.45)	0.78 (0.57 - 0.99)	3.4[E] (1.2 - 5.6)
60–79	1	1073	0.65	0.34 (0.28 - 0.40)	0.090 (0.079 - 0.10)	0.29 (0.24 - 0.34)	0.62 (0.42 - 0.82)	3.0 (1.9 - 4.1)
60–79	2	278	0	0.43[E] (0.29 - 0.64)	0.092 (0.073 - 0.11)	0.32 (0.24 - 0.41)	F	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 14.5.5.6

3-Phenoxybenzoic acid (3-PBA) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1252	0.08	0.31 (0.26 - 0.38)	0.088 (0.071 - 0.11)	0.27 (0.21 - 0.33)	0.54 (0.41 - 0.68)	2.7[E] (0.76 - 4.7)
Males, 6–11	1	522	0.38	0.31 (0.23 - 0.40)	0.096 (0.080 - 0.11)	0.24 (0.18 - 0.30)	0.51 (0.35 - 0.67)	3.1[E] (<LOD - 5.2)
Males, 6–11	2	261	0	0.34 (0.27 - 0.42)	0.14 (0.13 - 0.15)	0.26 (0.17 - 0.34)	0.52[E] (0.29 - 0.75)	F
Males, 12–19	1	500	0	0.22 (0.17 - 0.29)	0.062 (0.047 - 0.077)	0.18 (0.11 - 0.24)	0.41[E] (0.24 - 0.58)	1.9[E] (0.97 - 2.8)
Males, 12–19	2	252	0	0.22 (0.17 - 0.29)	0.073 (0.064 - 0.082)	0.17 (0.12 - 0.22)	F	2.4[E] (0.97 - 3.8)
Males, 20–39	1	509	0.39	0.24 (0.19 - 0.31)	0.072 (0.056 - 0.088)	0.19 (0.14 - 0.24)	0.39 (0.28 - 0.50)	2.0[E] (1.0 - 3.0)
Males, 20–39	2	160	0	0.28 (0.22 - 0.36)	0.099 (0.067 - 0.13)	0.29 (0.21 - 0.36)	0.47 (0.35 - 0.59)	x
Males, 40–59	1	571	0.70	0.30 (0.23 - 0.38)	0.071 (0.055 - 0.086)	0.25 (0.18 - 0.31)	0.64 (0.44 - 0.84)	2.8[E] (1.2 - 4.4)
Males, 40–59	2	184	0	0.36 (0.26 - 0.48)	0.10 (0.074 - 0.13)	0.27[E] (0.14 - 0.40)	0.71[E] (0.43 - 0.99)	x
Males, 60–79	1	535	0.56	0.28 (0.23 - 0.33)	0.075 (0.064 - 0.086)	0.24 (0.18 - 0.30)	0.51 (0.39 - 0.64)	2.3 (1.5 - 3.0)
Males, 60–79	2	137	0	0.32[E] (0.22 - 0.47)	0.064[E] (0.040 - 0.089)	0.30 (0.21 - 0.39)	0.57[E] (<LOD - 0.86)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1254	0	0.56 (0.43 - 0.72)	0.12 (0.10 - 0.14)	0.41 (0.31 - 0.51)	1.0[E] (0.57 - 1.4)	F
Females, 6–11	1	500	1.00	0.35 (0.27 - 0.44)	0.097 (0.065 - 0.13)	0.30 (0.24 - 0.37)	0.60 (0.39 - 0.81)	F
Females, 6–11	2	252	0	0.35 (0.27 - 0.46)	0.10 (0.079 - 0.13)	0.28 (0.19 - 0.37)	0.61[E] (0.27 - 0.94)	3.8[E] (<LOD - 5.5)
Females, 12–19	1	475	0.42	0.28 (0.20 - 0.38)	0.070 (0.050 - 0.089)	0.21 (0.14 - 0.28)	0.48 (0.35 - 0.60)	3.8[E] (2.4 - 5.2)
Females, 12–19	2	255	0	0.34 (0.26 - 0.43)	0.095 (0.068 - 0.12)	0.26 (0.20 - 0.32)	0.61[E] (0.18 - 1.0)	2.6[E] (1.5 - 3.8)
Females, 20–39	1	646	0.31	0.32 (0.25 - 0.42)	0.085 (0.056 - 0.11)	0.28 (0.21 - 0.36)	0.59 (0.45 - 0.73)	3.1[E] (1.7 - 4.4)
Females, 20–39	2	183	0	0.91[E] (0.48 - 1.7)	0.14[E] (0.071 - 0.21)	0.56[E] (0.22 - 0.89)	F	x
Females, 40–59	1	640	1.41	0.40 (0.32 - 0.49)	0.11 (0.089 - 0.12)	0.33 (0.27 - 0.39)	0.78[E] (0.48 - 1.1)	3.0 (2.3 - 3.6)
Females, 40–59	2	160	0	0.47 (0.35 - 0.63)	0.12[E] (0.078 - 0.17)	0.41 (0.28 - 0.53)	0.88[E] (0.42 - 1.3)	x
Females, 60–79	1	538	0.74	0.40 (0.32 - 0.50)	0.11 (0.093 - 0.12)	0.33 (0.25 - 0.42)	0.77 (0.51 - 1.0)	3.7[E] (1.5 - 6.0)
Females, 60–79	2	141	0	0.56[E] (0.31 - 1.0)	0.11 (0.084 - 0.14)	F	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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PHTHALATE METABOLITES SUMMARY AND RESULTS

15

Diesters of phthalic acid, also called phthalates, are a class of high-production volume industrial chemicals that are used in the manufacture of a variety of consumer products. Table 15.1 lists phthalates commonly found in commerce and their major metabolites measured in cycle 2 of the Canadian Health Measures Survey (CHMS).

Table 15.1

Phthalate metabolites measured in the Canadian Health Measures Survey cycle 2 (2009–2011) and their parent phthalate compounds.

Phthalate	CASRN	Metabolite	CASRN
Benzyl butyl phthalate, BBP	85-68-7	Mono-benzyl phthalate, MBzP (some M*n*BP)	2528-16-7
Di-*n*-butyl phthalate, D*n*BP	84-74-2	Mono-*n*-butyl phthalate, M*n*BP	131-70-4
Dicyclohexyl phthalate, DCHP	84-61-7	Mono-cyclohexyl phthalate, MCHP	7517-36-4
Diethyl phthalate, DEP	84-66-2	Mono-ethyl phthalate, MEP	2306-33-4
Di-isobutyl phthalate, DiBP	84-69-5	Mono-isobutyl phthalate, MiBP	30833-53-5
Di-isononyl phthalate, DiNP	28553-12-0, 68515-48-0	Mono-isononyl phthalate, MiNP	519056-28-1
Dimethyl phthalate, DMP	131-11-3	Mono-methyl phthalate, MMP	4376-18-5
Di-*n*-octyl phthalate, DOP	117-84-0	Mono-*n*-octyl phthalate, MOP Mono-3-carboxypropyl phthalate, MCPP	5393-19-1 66851-46-5
Di-2-ethylhexyl phthalate, DEHP	117-81-7	Mono-2-ethylhexyl phthalate, MEHP Mono-(2-ethyl-5-oxohexyl) phthalate, MEOHP Mono-(2-ethyl-5-hydroxyhexyl) phthalate, MEHHP	4376-20-9 40321-98-0 40321-99-1

Although some phthalates occur naturally in crude oil and coal, the vast majority are anthropogenic. Phthalates are primarily used as plasticizers to impart flexibility and resilience to plastics (Frederiksen et al., 2007; Graham, 1973). BBP is used in Canada in polyvinyl chloride (PVC) flooring and other materials, in paints and coatings, in adhesive formulations, and in printing inks (Environment Canada & Health Canada, 2000). DEP is the predominant phthalate used in fragrances, cosmetics, and personal-care products (Cosmetic Ingredient Review Expert Panel, 2005; Koniecki et al., 2011). DEHP is added to PVC for use in medical equipment including intravenous bags, blood bags, and various types of tubing (NTP-CERHR, 2006). DMP is used in plastics and consumer products such as insect repellents (Chen et al., 2011). D*n*BP is used mainly in polyvinyl emulsions, adhesives, and coatings (Environment Canada & Health Canada, 1994a). DCHP is used to stabilize rubbers, resins, and polymers, including nitrocellulose, polyvinyl acetate, and PVC (CDC, 2009). DiNP is used in PVC-based consumer products, inks, paints, and sealants (CDC, 2009). DOP is used in polymer manufacturing, particularly PVC, to make products such as gloves, flooring, and flexible sheets (Environment Canada & Health Canada, 1993). Phthalates, namely BBP, D*n*BP, DiNP, and DEHP, were also previously used in Canada as plasticizers in the soft vinyl of children's toys and child-care articles.

Phthalates can be released to the environment through air emissions during their manufacture and use, via waste waters from various industries, in municipal sewage, from the incomplete combustion of plastics, and from the use and disposal of consumer products (Environment Canada & Health Canada, 1993; Environment Canada & Health Canada, 1994a; Environment Canada & Health Canada, 1994b; Environment Canada & Health Canada, 2000). Phthalates have been detected in food, water, air, and dust (Clark, 2003).

For the general public, food and the use of consumer products made out of PVC plastics are the primary sources of exposure to phthalates (Fromme et al., 2007; Petersen & Breindahl, 2000; Tsumura et al., 2001; Wormuth et al., 2006). Because phthalates are not chemically bound to plastics used in consumer products, leaching could occur during use of the products.

In laboratory animals, phthalates have been observed to undergo rapid absorption following oral exposure and generally slow absorption following dermal exposure (ATSDR, 1995; ATSDR, 1997; ATSDR, 2001; ATSDR, 2002). In humans, phthalates are rapidly metabolized and do not bioaccumulate (CDC, 2009). Phthalate diesters are converted to their corresponding monoesters in the gastrointestinal tract or saliva prior to absorption (ATSDR, 1995; ATSDR, 1997; ATSDR, 2001; ATSDR, 2002; NRC, 2008). Primary metabolites may undergo further oxidative reactions in the liver to form secondary metabolites (Samandar et al., 2009). Phthalate metabolites can be excreted in urine unchanged or as glucuronic acid conjugates (Samandar et al., 2009). Although the metabolism and excretion of monoester phthalates varies based on a number of factors, they are generally characterized by rapid metabolism and short biological half-lives (ATSDR, 1995; ATSDR, 1997; ATSDR, 2001; ATSDR, 2002; Hauser & Calafat, 2005). Measurement of phthalate metabolites in urine has become the most common approach to assess phthalate exposure in humans and reflects relatively recent exposure (Blount et al., 2000; Calafat & McKee, 2006).

In laboratory animals, exposure to some phthalates adversely affects the male reproductive system. In particular, prenatal exposure to phthalates, such as D*n*BP, BBP and DEHP, has been shown to disrupt the androgen-mediated development of the male reproductive tract (David, 2006; Foster, 2005; Gray et al., 2000; Howdeshell et al., 2007; Main et al., 2006; Wine et al., 1997). Adverse effects on the testes have also been observed in mature laboratory animals, although these effects occurred at higher doses (David, 2006; Foster, 2005). Other target organs identified in animal studies include the liver and kidneys (David & Gans, 2003; Howdeshell et al., 2007; Main et al., 2006; Wine et al., 1997).

Human data on health effects are still very limited; however, there are multiple studies demonstrating human exposure to phthalates in the human population, including prenatal exposure (Becker et al., 2009; Blount et al., 2000; Marsee et al., 2006; NTP-CERHR, 2003a; NTP-CERHR, 2003b; NTP-CERHR, 2003c; NTP-CERHR, 2003d; NTP-CERHR, 2003e; NTP-CERHR, 2003f; NTP-CERHR, 2006; Silva et al., 2003). Although no causal relationship has been established, several studies suggest an association between urinary phthalate metabolite concentrations and adverse effects on development and reproduction, particularly the male reproductive system (Duty et al., 2005; Jensen et al., 2012; Jurewicz & Hanke, 2011; Liu et al., 2012; Main et al., 2006; Marsee et al., 2006; Philippat et al., 2011; Snijder et al., 2012; Swan et al., 2005). The International Agency for Research on Cancer has classified DEHP as Group 3, not classifiable as to its carcinogenicity to humans (IARC, 2000).

Several phthalates, including DEHP, have been assessed as priority substances by Environment Canada and Health Canada (Environment Canada & Health Canada, 1994b), D*n*BP (Environment Canada & Health Canada, 1994a), DOP (Environment Canada & Health Canada, 1993; Environment Canada & Health Canada, 2003), and BBP (Environment Canada & Health Canada, 2000). Based on assessments of available data, D*n*BP and BBP were not considered to be toxic as defined by the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; Environment Canada & Health Canada, 1994a; Environment Canada & Health Canada, 2000). Similarly, it was concluded that DOP does not pose an ecological concern, but available data were insufficient to conclude on human health (Environment Canada & Health Canada, 1993). DEHP was declared toxic under CEPA 1999 because it was considered to be a potential danger to human health based on available data (Environment Canada & Health Canada, 1994b). DCHP, DiNP, DiBP, and DMP have been identified as high-priority substances in Canada and will be assessed jointly by Health Canada and Environment Canada as part of the grouping initiative of the Chemicals Management Plan under the CEPA 1999 (Canada, 2011).

DEHP has recently been included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011). Recently, Health Canada has developed and implemented the *Phthalates Regulations*, on the use of six phthalates (DEHP, D*n*BP, BBP, DiNP, di-isodecyl phthalate, and DOP) in soft vinyl children's toys and child-care articles (Canada, 2010). This regulation restricts the same six phthalates as regulations in the United States and the European Union.

Eleven monoester phthalate metabolites (M*n*BP, MEP, MBzP, MCHP, MEHP, MOP, MiNP, MMP, MCPP, MEHHP, and MEOHP) were measured in the urine of all CHMS participants aged 6 to 49 years in cycle 1 (2007–2009) and 3 to 79 years in cycle 2 (2009–2011). MiBP was measured in the urine of all CHMS cycle 2 (2009–2011) participants aged 3 to 79 years. Data from these monoester phthalate metabolites are presented as both µg/L and µg/g creatinine (Tables 15.1.1 to 15.12.6). Finding a measurable amount of monoester phthalate metabolites in urine is an indicator of exposure to diester phthalates and does not necessarily mean that an adverse health effect will occur.

15.1 MONO-BENZYL PHTHALATE (MBzP)

Table 15.1.1

Mono-benzyl phthalate (MBzP) — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3235	0	12 (9.7 - 14)	2.2 (1.8 - 2.7)	12 (9.4 - 14)	28 (23 - 33)	81 (67 - 96)
Total, 6–49	2	1608	0	8.8 (7.5 - 10)	2.2 (1.7 - 2.7)	8.4 (6.8 - 10)	18 (15 - 21)	61 (51 - 70)
Males, Total 6–49	1	1629	0	12 (10 - 15)	2.2 (1.6 - 2.9)	14 (11 - 18)	30 (25 - 34)	81 (63 - 98)
Males, Total 6–49	2	809	0	9.2 (7.6 - 11)	2.4 (1.8 - 3.0)	9.0 (6.5 - 11)	18 (14 - 22)	60 (46 - 74)
Females, Total 6–49	1	1606	0	11 (8.9 - 13)	2.2 (1.7 - 2.8)	10 (8.0 - 12)	26 (21 - 32)	85 (68 - 100)
Females, Total 6–49	2	799	0	8.4 (6.6 - 11)	2.1[E] (1.3 - 2.9)	7.7 (5.1 - 10)	18 (14 - 22)	61[E] (34 - 88)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.1.2

Mono-benzyl phthalate (MBzP) — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2559	0	7.5 (6.5 - 8.6)	1.7 (1.3 - 2.2)	7.1 (6.1 - 8.1)	16 (13 - 19)	57 (48 - 65)
3–5[b]	1							
3–5	2	522	0	17 (14 - 20)	4.1[E] (2.6 - 5.7)	16 (13 - 18)	33 (23 - 44)	120 (86 - 150)
6–11	1	1037	0	21 (17 - 25)	4.8 (3.2 - 6.3)	21 (17 - 25)	45 (37 - 53)	120 (98 - 150)
6–11	2	516	0	19 (15 - 23)	4.9 (3.5 - 6.4)	20 (15 - 24)	35 (28 - 42)	100 (72 - 140)
12–19	1	991	0	19 (16 - 22)	4.4 (3.1 - 5.7)	20 (16 - 24)	36 (31 - 41)	99 (86 - 110)
12–19	2	512	0	12 (10 - 15)	3.3 (2.2 - 4.4)	12 (8.9 - 15)	25 (21 - 28)	59 (43 - 75)
20–39	1	730	0	10 (8.1 - 13)	2.0 (1.4 - 2.5)	9.9 (7.0 - 13)	25 (20 - 31)	77 (50 - 100)
20–39	2	359	0	7.3 (5.5 - 9.7)	1.8[E] (0.78 - 2.7)	7.0 (5.2 - 8.7)	14[E] (8.4 - 19)	60 (39 - 80)
40–59[b]	1							
40–59	2	360	0	6.0 (4.8 - 7.5)	1.6[E] (0.95 - 2.2)	5.6[E] (2.9 - 8.2)	13 (9.4 - 16)	F
60–79[b]	1							
60–79	2	290	0	5.2 (4.2 - 6.4)	1.0[E] (0.55 - 1.5)	4.7 (3.7 - 5.8)	11[E] (6.7 - 15)	36[E] (15 - 57)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.1.3

Mono-benzyl phthalate (MBzP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1281	0	8.0 (6.9 - 9.2)	2.1 (1.5 - 2.7)	7.5 (6.2 - 8.9)	16 (13 - 18)	54 (42 - 65)
Males, 6–11	1	525	0	21 (17 - 27)	4.9[E] (2.3 - 7.5)	20 (17 - 24)	46 (34 - 58)	120 (100 - 150)
Males, 6–11	2	262	0	20 (15 - 26)	4.7[E] (2.5 - 7.0)	21 (14 - 28)	36 (25 - 48)	120 (77 - 160)
Males, 12–19	1	506	0	18 (15 - 22)	4.3[E] (2.5 - 6.0)	19 (15 - 22)	32 (27 - 36)	88 (68 - 110)
Males, 12–19	2	256	0	13 (10 - 16)	4.1 (3.0 - 5.2)	13 (9.0 - 17)	24 (20 - 29)	60[E] (32 - 89)
Males, 20–39	1	366	0	12 (8.4 - 16)	2.0[E] (0.99 - 3.0)	12[E] (6.9 - 18)	29 (21 - 37)	80 (54 - 110)
Males, 20–39	2	168	0	8.2 (6.1 - 11)	2.0[E] (0.86 - 3.1)	7.6[E] (4.4 - 11)	16 (11 - 21)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	0	6.0 (4.6 - 7.8)	1.5[E] (0.69 - 2.4)	5.4[E] (2.4 - 8.4)	12 (8.9 - 15)	x
Males, 60–79[c]	1							
Males, 60–79	2	141	0	5.3 (3.8 - 7.3)	1.4[E] (0.75 - 2.1)	4.8 (3.3 - 6.3)	11[E] (4.8 - 16)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1278	0	7.1 (5.7 - 8.7)	1.5[E] (0.89 - 2.0)	6.7 (4.8 - 8.6)	16 (11 - 20)	58 (41 - 75)
Females, 6–11	1	512	0	21 (16 - 27)	4.7[E] (2.6 - 6.7)	22 (14 - 29)	45 (31 - 58)	100 (66 - 130)
Females, 6–11	2	254	0	18 (14 - 23)	5.0 (3.7 - 6.3)	18 (13 - 22)	31[E] (19 - 44)	90[E] (38 - 140)
Females, 12–19	1	485	0	20 (16 - 24)	4.4 (2.8 - 6.0)	21 (15 - 27)	41 (29 - 53)	110 (78 - 140)
Females, 12–19	2	256	0	12 (9.2 - 15)	2.4[E] (1.2 - 3.6)	11 (7.5 - 15)	26 (17 - 34)	57[E] (34 - 80)
Females, 20–39	1	364	0	9.3 (7.0 - 12)	1.9 (1.2 - 2.6)	8.7 (6.0 - 11)	24 (16 - 32)	65[E] (36 - 93)
Females, 20–39	2	191	0	6.5[E] (4.4 - 9.4)	F	5.4[E] (2.6 - 8.2)	12[E] (7.1 - 18)	x
Females, 40–59[c]	1							
Females, 40–59	2	166	0	6.0[E] (4.1 - 8.9)	1.6[E] (0.82 - 2.5)	6.2[E] (2.6 - 9.7)	14[E] (6.5 - 22)	x
Females, 60–79[c]	1							
Females, 60–79	2	149	0	5.1 (3.8 - 7.0)	0.92 (0.61 - 1.2)	4.5[E] (2.9 - 6.2)	12[E] (5.2 - 19)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.1.4

Mono-benzyl phthalate (MBzP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3227	0	13 (11 - 15)	3.7 (2.6 - 4.8)	12 (10 - 14)	24 (19 - 28)	70 (59 - 81)
Total, 6–49	2	1600	0	7.7 (6.5 - 9.2)	2.4 (1.8 - 3.0)	7.2 (5.7 - 8.6)	13 (9.4 - 17)	43 (36 - 50)
Males, Total 6–49	1	1623	0	12 (9.7 - 14)	3.0[E] (1.8 - 4.1)	11 (9.4 - 13)	20 (16 - 24)	61 (45 - 78)
Males, Total 6–49	2	806	0	7.3 (6.2 - 8.6)	2.5 (1.9 - 3.0)	6.4 (5.1 - 7.6)	12 (9.3 - 15)	39 (26 - 53)
Females, Total 6–49	1	1604	0	14 (12 - 17)	4.6 (3.6 - 5.6)	13 (11 - 15)	28 (23 - 33)	74 (59 - 89)
Females, Total 6–49	2	794	0	8.2 (6.4 - 11)	2.3[E] (1.2 - 3.4)	8.2 (5.9 - 10)	16[E] (9.4 - 22)	46 (39 - 53)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.1.5

Mono-benzyl phthalate (MBzP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2549	0	7.4 (6.4 - 8.6)	2.2 (1.9 - 2.6)	6.8 (5.7 - 8.0)	13 (11 - 16)	44 (37 - 51)
3–5[b]	1							
3–5	2	521	0	29 (24 - 35)	9.4 (7.6 - 11)	26 (20 - 32)	53 (39 - 67)	160 (110 - 200)
6–11	1	1034	0	32 (27 - 39)	10 (8.5 - 12)	31 (25 - 37)	55 (46 - 65)	140 (110 - 170)
6–11	2	514	0	22 (18 - 26)	6.2 (4.3 - 8.2)	21 (17 - 25)	39 (32 - 47)	98 (77 - 120)
12–19	1	989	0	16 (14 - 19)	5.6 (4.1 - 7.1)	15 (13 - 17)	27 (22 - 33)	70 (57 - 83)
12–19	2	510	0	9.4 (7.7 - 12)	3.2 (2.5 - 3.9)	9.4 (7.5 - 11)	16 (13 - 19)	44 (34 - 54)
20–39	1	728	0	11 (8.8 - 13)	3.0 (1.9 - 4.0)	10 (8.1 - 12)	19 (15 - 23)	54 (42 - 65)
20–39	2	357	0	6.3 (4.8 - 8.4)	2.0[E] (1.2 - 2.9)	5.6 (4.0 - 7.3)	11 (8.4 - 14)	36 (26 - 46)
40–59[b]	1							
40–59	2	358	0	6.1 (5.0 - 7.3)	2.1 (1.7 - 2.5)	5.5 (3.5 - 7.4)	11 (7.8 - 13)	28[E] (16 - 40)
60–79[b]	1							
60–79	2	289	0	6.0 (5.2 - 7.1)	2.0 (1.5 - 2.4)	5.8 (4.5 - 7.1)	11 (7.7 - 14)	27[E] (7.9 - 46)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 15.1.6

Mono-benzyl phthalate (MBzP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1277	0	6.8 (6.0 - 7.7)	2.2 (1.9 - 2.5)	5.9 (4.9 - 6.8)	12 (9.2 - 14)	39 (28 - 50)
Males, 6–11	1	523	0	33 (28 - 38)	10 (9.1 - 12)	32 (25 - 38)	56 (43 - 70)	140 (110 - 170)
Males, 6–11	2	261	0	23 (18 - 29)	5.8[E] (3.4 - 8.2)	23 (16 - 29)	43 (32 - 54)	96 (75 - 120)
Males, 12–19	1	505	0	15 (13 - 17)	5.4 (4.2 - 6.6)	15 (13 - 17)	23 (19 - 26)	64 (52 - 75)
Males, 12–19	2	255	0	9.2 (7.4 - 12)	3.1 (2.2 - 3.9)	9.4 (7.4 - 11)	15 (11 - 19)	37[E] (22 - 52)
Males, 20–39	1	364	0	9.7 (7.5 - 13)	2.7 (1.7 - 3.6)	9.6 (7.0 - 12)	18 (14 - 22)	44[E] (17 - 70)
Males, 20–39	2	167	0	6.1 (4.6 - 8.2)	2.3[E] (1.4 - 3.2)	5.7 (4.3 - 7.1)	9.5 (6.5 - 13)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	0	5.1 (4.4 - 6.0)	1.9 (1.4 - 2.4)	4.9 (4.3 - 5.5)	7.6 (6.7 - 8.5)	x
Males, 60–79[c]	1							
Males, 60–79	2	141	0	5.0 (3.9 - 6.4)	1.6 (1.1 - 2.1)	4.6[E] (2.8 - 6.4)	9.7[E] (6.2 - 13)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1272	0	8.1 (6.5 - 9.9)	2.2 (1.5 - 3.0)	7.7 (5.6 - 9.8)	15 (11 - 19)	46 (40 - 52)
Females, 6–11	1	511	0	32 (26 - 40)	10 (6.9 - 13)	30 (23 - 38)	55 (45 - 65)	F
Females, 6–11	2	253	0	21 (17 - 26)	6.9 (4.5 - 9.4)	21 (16 - 26)	34 (26 - 41)	110[E] (66 - 150)
Females, 12–19	1	484	0	17 (14 - 21)	5.8[E] (3.4 - 8.2)	16 (12 - 19)	32 (24 - 40)	77 (60 - 94)
Females, 12–19	2	255	0	9.6 (7.5 - 12)	3.4 (2.7 - 4.2)	8.9 (6.2 - 12)	16 (12 - 20)	45 (33 - 57)
Females, 20–39	1	364	0	12 (9.9 - 15)	4.1[E] (2.4 - 5.7)	11 (8.5 - 14)	21 (15 - 27)	55 (44 - 66)
Females, 20–39	2	190	0	6.5[E] (4.4 - 9.6)	1.9[E] (0.64 - 3.1)	5.4[E] (1.8 - 9.0)	12[E] (5.6 - 19)	x
Females, 40–59[c]	1							
Females, 40–59	2	164	0	7.2 (5.4 - 9.6)	2.2[E] (1.4 - 3.1)	7.6[E] (4.5 - 11)	13 (8.5 - 17)	x
Females, 60–79[c]	1							
Females, 60–79	2	148	0	7.2 (5.6 - 9.3)	2.2[E] (1.2 - 3.2)	6.4 (4.6 - 8.2)	12[E] (6.9 - 18)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.2 MONO-*n*-BUTYL PHTHALATE (M*n*BP)

Table 15.2.1

Mono-*n*-butyl phthalate (M*n*BP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3235	0.03	23 (21 - 25)	6.1 (4.9 - 7.2)	23 (20 - 26)	46 (42 - 51)	120 (90 - 150)
Total, 6–49	2	1605	0	22 (20 - 25)	6.9 (5.5 - 8.3)	22 (19 - 25)	37 (31 - 43)	90 (77 - 100)
Males, Total 6–49	1	1629	0	23 (20 - 26)	6.4 (4.6 - 8.2)	24 (21 - 28)	44 (37 - 51)	110 (82 - 150)
Males, Total 6–49	2	808	0	23 (19 - 27)	6.5[E] (4.0 - 9.0)	23 (18 - 28)	40 (33 - 48)	99[E] (55 - 140)
Females, Total 6–49	1	1606	0.06	23 (21 - 26)	5.8 (4.6 - 7.0)	22 (19 - 25)	48 (43 - 54)	120 (86 - 160)
Females, Total 6–49	2	797	0	21 (19 - 24)	7.1 (5.4 - 8.9)	21 (17 - 25)	35 (30 - 41)	86 (67 - 110)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.2.2

Mono-*n*-butyl phthalate (M*n*BP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2555	0	20 (18 - 22)	5.7 (4.3 - 7.1)	20 (18 - 22)	36 (33 - 39)	87 (74 - 100)
3–5[b]	1							
3–5	2	522	0	32 (28 - 37)	11 (8.0 - 14)	30 (26 - 34)	56 (43 - 69)	130 (110 - 150)
6–11	1	1037	0	33 (29 - 38)	8.6 (6.4 - 11)	32 (27 - 38)	66 (58 - 75)	160 (130 - 200)
6–11	2	515	0	36 (30 - 44)	9.7 (7.7 - 12)	32 (26 - 37)	58 (45 - 72)	F
12–19	1	991	0	32 (29 - 35)	9.1 (7.4 - 11)	33 (29 - 36)	55 (47 - 63)	140 (130 - 140)
12–19	2	512	0	28 (25 - 33)	9.1 (7.0 - 11)	28 (23 - 33)	50 (42 - 59)	110 (81 - 130)
20–39	1	730	0.14	22 (20 - 25)	6.0 (4.2 - 7.8)	22 (18 - 27)	43 (36 - 50)	100[E] (34 - 170)
20–39	2	358	0	20 (16 - 25)	6.3[E] (3.9 - 8.7)	21 (16 - 26)	36 (29 - 43)	77 (56 - 99)
40–59[b]	1							
40–59	2	357	0	17 (14 - 21)	4.0[E] (1.8 - 6.2)	17 (15 - 20)	29 (23 - 34)	83 (57 - 110)
60–79[b]	1							
60–79	2	291	0	17 (14 - 21)	5.3 (3.6 - 7.0)	16 (12 - 19)	30[E] (19 - 41)	81[E] (34 - 130)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.2.3

Mono-*n*-butyl phthalate (M*n*BP) — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1279	0	21 (18 - 24)	6.4 (4.7 - 8.1)	21 (18 - 24)	37 (30 - 44)	96 (70 - 120)
Males, 6–11	1	525	0	31 (24 - 39)	8.2[E] (4.8 - 11)	29 (23 - 35)	62 (49 - 75)	150 (99 - 200)
Males, 6–11	2	261	0	37 (26 - 52)	9.7 (7.7 - 12)	30 (23 - 38)	65[E] (26 - 100)	F
Males, 12–19	1	506	0	29 (26 - 33)	8.5 (6.7 - 10)	30 (27 - 34)	51 (42 - 60)	110 (81 - 140)
Males, 12–19	2	256	0	31 (25 - 37)	10 (7.2 - 13)	29 (22 - 36)	51 (34 - 67)	F
Males, 20–39	1	366	0	23 (19 - 28)	7.0[E] (3.4 - 11)	24 (19 - 30)	43 (33 - 53)	110[E] (54 - 160)
Males, 20–39	2	168	0	22 (18 - 27)	5.9[E] (2.3 - 9.4)	23 (16 - 30)	44 (34 - 53)	x
Males, 40–59[c]	1							
Males, 40–59	2	192	0	16 (13 - 21)	F	17 (14 - 20)	29 (19 - 39)	x
Males, 60–79[c]	1							
Males, 60–79	2	142	0	18 (14 - 23)	6.7 (4.7 - 8.7)	16 (13 - 19)	29 (22 - 36)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1276	0	19 (17 - 22)	5.2[E] (3.3 - 7.2)	19 (16 - 22)	33 (27 - 40)	86 (70 - 100)
Females, 6–11	1	512	0	36 (32 - 41)	9.4 (6.5 - 12)	36 (29 - 43)	70 (57 - 83)	170 (120 - 210)
Females, 6–11	2	254	0	35 (27 - 46)	9.8[E] (5.5 - 14)	33 (25 - 41)	54 (46 - 63)	F
Females, 12–19	1	485	0	35 (32 - 38)	10[E] (6.1 - 14)	36 (31 - 42)	62 (52 - 73)	140 (120 - 150)
Females, 12–19	2	256	0	26 (22 - 32)	6.4[E] (3.2 - 9.5)	26 (18 - 35)	50 (41 - 59)	100 (75 - 120)
Females, 20–39	1	364	0.27	22 (19 - 25)	5.6 (4.1 - 7.1)	21 (16 - 25)	42 (32 - 52)	F
Females, 20–39	2	190	0	18 (13 - 23)	6.5[E] (2.7 - 10)	19[E] (11 - 27)	29 (19 - 38)	x
Females, 40–59[c]	1							
Females, 40–59	2	165	0	17 (13 - 23)	F	17 (14 - 21)	29 (19 - 38)	x
Females, 60–79[c]	1							
Females, 60–79	2	149	0	16 (12 - 22)	4.2[E] (2.2 - 6.2)	15 (9.8 - 20)	34[E] (15 - 52)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.2.4

Mono-*n*-butyl phthalate (M*n*BP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3227	0.03	26 (24 - 28)	10 (9.6 - 11)	23 (21 - 24)	38 (33 - 42)	100 (78 - 120)
Total, 6–49	2	1597	0	19 (18 - 21)	8.7 (7.6 - 9.9)	17 (15 - 19)	27 (22 - 32)	72 (54 - 91)
Males, Total 6–49	1	1623	0	22 (20 - 23)	9.3 (8.3 - 10)	20 (19 - 21)	31 (28 - 33)	83 (60 - 110)
Males, Total 6–49	2	805	0	18 (17 - 20)	7.6 (6.5 - 8.7)	16 (14 - 18)	26 (21 - 30)	78 (51 - 110)
Females, Total 6–49	1	1604	0.06	31 (28 - 34)	13 (11 - 15)	27 (23 - 32)	45 (40 - 49)	120 (79 - 170)
Females, Total 6–49	2	792	0	21 (18 - 24)	10 (8.5 - 12)	18 (16 - 21)	29 (22 - 35)	65[E] (37 - 92)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.2.5

Mono-*n*-butyl phthalate (M*n*BP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2545	0	20 (18 - 21)	8.8 (7.8 - 9.8)	18 (16 - 20)	29 (25 - 33)	78 (65 - 92)
3–5[b]	1							
3–5	2	521	0	56 (49 - 64)	27 (23 - 30)	52 (46 - 59)	79 (63 - 95)	170 (110 - 230)
6–11	1	1034	0	51 (46 - 56)	22 (19 - 25)	45 (40 - 51)	74 (61 - 86)	210 (140 - 270)
6–11	2	513	0	42 (36 - 48)	17 (15 - 19)	35 (30 - 40)	58 (47 - 70)	F
12–19	1	989	0	27 (25 - 30)	12 (11 - 13)	25 (23 - 27)	36 (28 - 43)	99 (89 - 110)
12–19	2	510	0	22 (19 - 25)	10 (9.1 - 12)	20 (17 - 23)	30 (26 - 35)	62 (48 - 75)
20–39	1	728	0.14	23 (21 - 26)	9.9 (8.5 - 11)	21 (19 - 22)	33 (28 - 38)	F
20–39	2	356	0	17 (15 - 20)	8.5 (7.1 - 9.9)	15 (12 - 17)	23 (17 - 28)	47[E] (15 - 78)
40–59[b]	1							
40–59	2	355	0	17 (15 - 19)	7.3 (5.9 - 8.7)	16 (14 - 19)	25 (21 - 28)	55[E] (18 - 92)
60–79[b]	1							
60–79	2	290	0	20 (17 - 23)	9.3 (7.6 - 11)	18 (14 - 23)	32 (26 - 38)	72 (62 - 82)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.2.6

Mono-*n*-butyl phthalate (M*n*BP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1275	0	18 (16 - 20)	7.6 (7.0 - 8.3)	16 (14 - 18)	27 (22 - 31)	74 (61 - 86)
Males, 6–11	1	523	0	47 (43 - 50)	21 (19 - 23)	42 (38 - 47)	63 (48 - 79)	140[E] (71 - 200)
Males, 6–11	2	260	0	42 (31 - 58)	17 (15 - 20)	34 (26 - 42)	57[E] (27 - 87)	F
Males, 12–19	1	505	0	24 (22 - 28)	11 (9.5 - 12)	22 (20 - 25)	33 (25 - 40)	99 (80 - 120)
Males, 12–19	2	255	0	22 (18 - 27)	10 (8.7 - 11)	19 (14 - 23)	32 (21 - 43)	74[E] (<LOD - 120)
Males, 20–39	1	364	0	19 (17 - 21)	8.2 (6.6 - 9.8)	19 (16 - 22)	26 (22 - 30)	56 (39 - 73)
Males, 20–39	2	167	0	17 (15 - 18)	8.0 (6.2 - 9.9)	14 (12 - 16)	22 (17 - 27)	x
Males, 40–59[c]	1							
Males, 40–59	2	192	0	14 (12 - 16)	6.4 (5.5 - 7.3)	13 (10 - 15)	19 (13 - 24)	x
Males, 60–79[c]	1							
Males, 60–79	2	142	0	17 (13 - 21)	8.0[E] (4.9 - 11)	16 (12 - 19)	24[E] (14 - 35)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1270	0	22 (19 - 24)	10 (8.7 - 12)	19 (16 - 23)	31 (26 - 37)	83 (64 - 100)
Females, 6–11	1	511	0	55 (48 - 64)	22 (17 - 27)	49 (43 - 56)	80 (62 - 97)	220[E] (110 - 340)
Females, 6–11	2	253	0	41 (33 - 50)	16 (12 - 21)	35 (29 - 42)	59 (45 - 72)	160[E] (72 - 250)
Females, 12–19	1	484	0	31 (28 - 34)	15 (13 - 17)	26 (23 - 29)	40 (33 - 47)	99[E] (60 - 140)
Females, 12–19	2	255	0	21 (19 - 24)	11 (9.1 - 13)	21 (18 - 24)	29 (25 - 32)	52 (46 - 58)
Females, 20–39	1	364	0.27	29 (25 - 32)	12 (9.7 - 14)	25 (21 - 29)	45 (39 - 50)	120[E] (<LOD - 200)
Females, 20–39	2	189	0	17 (14 - 22)	8.7 (6.0 - 11)	16 (12 - 19)	23 (16 - 29)	x
Females, 40–59[c]	1							
Females, 40–59	2	163	0	20 (17 - 25)	10 (6.9 - 14)	19 (14 - 24)	25 (21 - 30)	x
Females, 60–79[c]	1							
Females, 60–79	2	148	0	23 (18 - 29)	11 (8.7 - 13)	23 (15 - 30)	35[E] (22 - 48)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.3 MONO-CYCLOHEXYL PHTHALATE (MCHP)

Table 15.3.1

Mono-cyclohexyl phthalate (MCHP) — Geometric means and selected percentiles of urine concentrations (µg/L) f or the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3235	87.23	—	<LOD	<LOD	<LOD	0.89[E] (0.46 - 1.3)
Total, 6–49	2	1602	72.41	—	<LOD	<LOD	<LOD	0.45 (0.32 - 0.58)
Males, Total 6–49	1	1629	88.77	—	<LOD	<LOD	<LOD	0.50[E] (<LOD - 0.81)
Males, Total 6–49	2	807	73.48	—	<LOD	<LOD	F	F
Females, Total 6–49	1	1606	85.68	—	<LOD	<LOD	<LOD	1.1[E] (0.52 - 1.7)
Females, Total 6–49	2	795	71.32	—	<LOD	<LOD	<LOD	0.44 (0.33 - 0.55)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 15.3.2

Mono-cyclohexyl phthalate (MCHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2551	71.70	—	<LOD	<LOD	F	0.47[E] (0.28 - 0.67)
3–5[b]	1							
3–5	2	522	68.20	—	<LOD	<LOD	0.13[E] (<LOD - 0.22)	F
6–11	1	1037	85.44	—	<LOD	<LOD	<LOD	1.1[E] (0.48 - 1.7)
6–11	2	516	67.25	—	<LOD	<LOD	0.15[E] (<LOD - 0.23)	1.3[E] (0.46 - 2.0)
12–19	1	991	87.99	—	<LOD	<LOD	<LOD	1.1[E] (0.59 - 1.6)
12–19	2	507	73.37	—	<LOD	<LOD	F	F
20–39	1	730	88.77	—	<LOD	<LOD	<LOD	0.86[E] (0.45 - 1.3)
20–39	2	359	75.49	—	<LOD	<LOD	F	0.33[E] (0.19 - 0.47)
40–59[b]	1							
40–59	2	358	76.26	—	<LOD	<LOD	<LOD	F
60–79[b]	1							
60–79	2	289	72.66	—	<LOD	<LOD	<LOD[E] (<LOD - 0.12)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.3.3

Mono-cyclohexyl phthalate (MCHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1278	73.55	—	<LOD	<LOD	F	0.57[E] (0.29 - 0.84)
Males, 6–11	1	525	86.86	—	<LOD	<LOD	<LOD	F
Males, 6–11	2	262	69.85	—	<LOD	<LOD	F	1.4[E] (0.48 - 2.4)
Males, 12–19	1	506	89.72	—	<LOD	<LOD	<LOD	F
Males, 12–19	2	254	75.59	—	<LOD	<LOD	<LOD	0.57[E] (0.35 - 0.79)
Males, 20–39	1	366	90.44	—	<LOD	<LOD	<LOD	0.62[E] (0.22 - 1.0)
Males, 20–39	2	168	72.02	—	<LOD	<LOD	F	x
Males, 40–59[c]	1							
Males, 40–59	2	193	75.13	—	<LOD	<LOD	<LOD	x
Males, 60–79[c]	1							
Males, 60–79	2	141	77.30	—	<LOD	<LOD	<LOD	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1273	69.84	—	<LOD	<LOD	F	0.44 (0.30 - 0.59)
Females, 6–11	1	512	83.98	—	<LOD	<LOD	<LOD	1.1 (0.87 - 1.3)
Females, 6–11	2	254	64.57	—	<LOD	<LOD	0.18[E] (0.092 - 0.26)	F
Females, 12–19	1	485	86.19	—	<LOD	<LOD	<LOD	1.3[E] (0.70 - 2.0)
Females, 12–19	2	253	71.15	—	<LOD	<LOD	F	F
Females, 20–39	1	364	87.09	—	<LOD	<LOD	<LOD	0.96[E] (0.46 - 1.5)
Females, 20–39	2	191	78.53	—	<LOD	<LOD	<LOD	x
Females, 40–59[c]	1							
Females, 40–59	2	165	77.58	—	<LOD	<LOD	<LOD	x
Females, 60–79[c]	1							
Females, 60–79	2	148	68.24	—	<LOD	<LOD	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.3.4

Mono-cyclohexyl phthalate (MCHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3227	87.46	—	<LOD	<LOD	<LOD	0.94[E] (0.59 - 1.3)
Total, 6–49	2	1594	71.98	—	<LOD	<LOD	<LOD	0.44[E] (0.26 - 0.61)
Males, Total 6–49	1	1623	89.10	—	<LOD	<LOD	<LOD	0.71 (<LOD - 0.96)
Males, Total 6–49	2	804	73.78	—	<LOD	<LOD	<LOD	0.55[E] (<LOD - 0.80)
Females, Total 6–49	1	1604	85.79	—	<LOD	<LOD	<LOD	F
Females, Total 6–49	2	790	70.17	—	<LOD	<LOD	<LOD	0.37[E] (0.22 - 0.52)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 15.3.5

Mono-cyclohexyl phthalate (MCHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2541	71.98	—	<LOD	<LOD	<LOD (<LOD - 0.16)	0.55[E] (0.33 - 0.78)
3–5[b]	1							
3–5	2	521	68.33	—	<LOD	<LOD	0.34[E] (<LOD - 0.49)	F
6–11	1	1034	85.69	—	<LOD	<LOD	<LOD	1.9[E] (0.92 - 2.8)
6–11	2	514	67.51	—	<LOD	<LOD	0.21[E] (<LOD - 0.29)	F
12–19	1	989	88.17	—	<LOD	<LOD	<LOD	0.82[E] (0.39 - 1.2)
12–19	2	505	73.66	—	<LOD	<LOD	<LOD (<LOD - 0.14)	F
20–39	1	728	89.01	—	<LOD	<LOD	<LOD	0.86 (0.67 - 1.0)
20–39	2	357	75.91	—	<LOD	<LOD	<LOD (<LOD - 0.15)	0.34[E] (0.11 - 0.56)
40–59[b]	1							
40–59	2	356	76.69	—	<LOD	<LOD	<LOD	F
60–79[b]	1							
60–79	2	288	72.92	—	<LOD	<LOD	<LOD (<LOD - 0.25)	0.44[E] (0.26 - 0.63)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.3.6

Mono-cyclohexyl phthalate (MCHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1274	73.78	—	<LOD	<LOD	<LOD (<LOD - 0.15)	0.55 (0.37 - 0.73)
Males, 6–11	1	523	87.19	—	<LOD	<LOD	<LOD	F
Males, 6–11	2	261	70.11	—	<LOD	<LOD	F	F
Males, 12–19	1	505	89.90	—	<LOD	<LOD	<LOD	0.66[E] (<LOD - 1.1)
Males, 12–19	2	253	75.89	—	<LOD	<LOD	<LOD	F
Males, 20–39	1	364	90.93	—	<LOD	<LOD	<LOD	0.66[E] (0.32 - 1.0)
Males, 20–39	2	167	72.46	—	<LOD	<LOD	<LOD (<LOD - 0.17)	x
Males, 40–59[c]	1							
Males, 40–59	2	193	75.13	—	<LOD	<LOD	<LOD	x
Males, 60–79[c]	1							
Males, 60–79	2	141	77.30	—	<LOD	<LOD	<LOD	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1267	70.17	—	<LOD	<LOD	<LOD (<LOD - 0.20)	F
Females, 6–11	1	511	84.15	—	<LOD	<LOD	<LOD	1.8[E] (0.98 - 2.6)
Females, 6–11	2	253	64.82	—	<LOD	<LOD	0.23[E] (0.14 - 0.31)	F
Females, 12–19	1	484	86.36	—	<LOD	<LOD	<LOD	F
Females, 12–19	2	252	71.43	—	<LOD	<LOD	<LOD (<LOD - 0.16)	F
Females, 20–39	1	364	87.09	—	<LOD	<LOD	<LOD	1.0 (0.70 - 1.4)
Females, 20–39	2	190	78.95	—	<LOD	<LOD	<LOD	x
Females, 40–59[c]	1							
Females, 40–59	2	163	78.53	—	<LOD	<LOD	<LOD	x
Females, 60–79[c]	1							
Females, 60–79	2	147	68.71	—	<LOD	<LOD	<LOD (<LOD - 0.29)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.4 MONO-ETHYL PHTHALATE (MEP)

Table 15.4.1

Mono-ethyl phthalate (MEP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3235	0.03	56 (47 - 66)	9.9 (8.3 - 12)	49 (40 - 57)	140 (110 - 170)	810[E] (340 - 1300)
Total, 6–49	2	1608	0	45 (36 - 56)	7.7 (5.8 - 9.5)	42 (33 - 52)	110 (92 - 130)	460[E] (230 - 700)
Males, Total 6–49	1	1629	0.06	59 (48 - 72)	10 (8.5 - 11)	49 (40 - 59)	150 (100 - 190)	910[E] (380 - 1400)
Males, Total 6–49	2	809	0	45 (34 - 61)	8.6 (6.5 - 11)	36[E] (23 - 50)	120[E] (71 - 160)	F
Females, Total 6–49	1	1606	0	53 (44 - 65)	9.7 (7.6 - 12)	49 (36 - 61)	130 (96 - 160)	F
Females, Total 6–49	2	799	0	45 (36 - 56)	7.2 (5.2 - 9.2)	46 (35 - 58)	110 (78 - 140)	380[E] (150 - 620)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 15.4.2

Mono-ethyl phthalate (MEP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2561	0	44 (36 - 54)	7.6 (6.0 - 9.2)	42 (35 - 50)	100 (76 - 130)	F
3–5[b]	1							
3–5	2	523	0	21 (18 - 24)	6.8 (5.4 - 8.2)	19 (16 - 23)	40 (30 - 51)	120 (92 - 140)
6–11	1	1037	0.10	26 (21 - 32)	6.3 (4.5 - 8.0)	23 (19 - 28)	53 (38 - 69)	200[E] (120 - 290)
6–11	2	516	0	29 (23 - 37)	6.6 (4.4 - 8.8)	25[E] (14 - 36)	65 (42 - 88)	240[E] (110 - 380)
12–19	1	991	0	65 (55 - 77)	14 (9.7 - 18)	60 (47 - 73)	130 (110 - 150)	550[E] (320 - 780)
12–19	2	512	0	51 (43 - 61)	10 (7.1 - 14)	47 (38 - 57)	110 (95 - 130)	490[E] (270 - 710)
20–39	1	730	0	62 (51 - 75)	11 (7.3 - 14)	51 (35 - 68)	150 (110 - 200)	F
20–39	2	359	0	48[E] (31 - 73)	7.6 (4.8 - 10)	45[E] (25 - 65)	120[E] (47 - 190)	F
40–59[b]	1							
40–59	2	360	0	44[E] (29 - 69)	6.9[E] (3.1 - 11)	43[E] (27 - 60)	110[E] (54 - 170)	F
60–79[b]	1							
60–79	2	291	0	49 (38 - 62)	9.1 (6.8 - 11)	44 (33 - 56)	89 (71 - 110)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.4.3

Mono-ethyl phthalate (MEP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1282	0	45 (34 - 60)	8.8 (7.3 - 10)	38 (25 - 50)	110 (76 - 150)	F
Males, 6–11	1	525	0.19	23 (17 - 32)	5.8[E] (3.4 - 8.1)	20 (14 - 25)	47[E] (22 - 72)	150[E] (83 - 210)
Males, 6–11	2	262	0	25 (18 - 34)	6.4 (5.2 - 7.7)	21[E] (7.9 - 34)	55[E] (31 - 79)	110 (84 - 140)
Males, 12–19	1	506	0	57 (47 - 68)	12[E] (7.1 - 18)	49 (42 - 57)	110 (88 - 140)	F
Males, 12–19	2	256	0	45 (37 - 56)	11 (7.7 - 13)	39[E] (20 - 58)	94 (65 - 120)	300[E] (88 - 520)
Males, 20–39	1	366	0	75 (53 - 110)	13[E] (7.3 - 19)	67[E] (33 - 100)	190[E] (54 - 320)	F
Males, 20–39	2	168	0	53[E] (29 - 97)	9.1[E] (2.7 - 16)	44[E] (13 - 75)	190[E] (71 - 310)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	0	48[E] (28 - 83)	8.8[E] (4.6 - 13)	F	F	x
Males, 60–79[c]	1							
Males, 60–79	2	142	0	46 (36 - 60)	8.4[E] (5.1 - 12)	43 (31 - 54)	88 (63 - 110)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1279	0	43 (36 - 53)	6.9 (5.0 - 8.7)	45 (35 - 54)	92 (67 - 120)	F
Females, 6–11	1	512	0	29 (25 - 34)	6.9 (5.0 - 8.7)	28 (23 - 33)	61 (44 - 78)	260[E] (140 - 380)
Females, 6–11	2	254	0	35 (26 - 46)	8.2 (6.2 - 10)	28[E] (14 - 41)	70[E] (24 - 120)	270[E] (150 - 390)
Females, 12–19	1	485	0	75 (62 - 89)	16 (11 - 20)	72 (54 - 90)	150 (110 - 190)	500[E] (260 - 740)
Females, 12–19	2	256	0	58 (45 - 75)	F	52 (40 - 64)	120[E] (72 - 170)	F
Females, 20–39	1	364	0	50 (41 - 62)	10[E] (6.0 - 14)	45 (30 - 60)	120 (86 - 150)	F
Females, 20–39	2	191	0	43[E] (28 - 66)	6.8[E] (4.3 - 9.4)	48[E] (27 - 69)	110[E] (49 - 170)	x
Females, 40–59[c]	1							
Females, 40–59	2	166	0	41[E] (24 - 70)	F	45[E] (24 - 65)	91[E] (47 - 130)	x
Females, 60–79[c]	1							
Females, 60–79	2	149	0	51[E] (34 - 78)	9.2[E] (4.8 - 14)	45[E] (25 - 65)	89 (59 - 120)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.4.4

Mono-ethyl phthalate (MEP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3227	0.03	62 (54 - 71)	14 (13 - 16)	53 (46 - 61)	120 (100 - 140)	690[E] (300 - 1100)
Total, 6–49	2	1600	0	40 (34 - 48)	10 (7.8 - 13)	34 (26 - 41)	82 (54 - 110)	F
Males, Total 6–49	1	1623	0.06	55 (47 - 64)	12 (10 - 14)	46 (37 - 55)	110 (88 - 130)	F
Males, Total 6–49	2	806	0	37 (29 - 46)	9.3 (7.1 - 12)	26 (18 - 35)	95[E] (57 - 130)	330[E] (<LOD - 540)
Females, Total 6–49	1	1604	0	70 (60 - 83)	17 (15 - 18)	60 (54 - 67)	130 (100 - 160)	F
Females, Total 6–49	2	794	0	44 (35 - 56)	13 (11 - 16)	41 (32 - 50)	81 (56 - 110)	F

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 15.4.5

Mono-ethyl phthalate (MEP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2551	0	44 (37 - 52)	11 (8.9 - 13)	38 (30 - 45)	88 (63 - 110)	410[E] (<LOD - 630)
3–5[b]	1							
3–5	2	522	0	36 (32 - 41)	14 (12 - 17)	31 (26 - 36)	54[E] (33 - 75)	180 (130 - 230)
6–11	1	1034	0.10	40 (33 - 48)	14 (12 - 16)	33 (27 - 38)	61 (48 - 75)	210[E] (97 - 320)
6–11	2	514	0	34 (27 - 42)	11 (8.7 - 12)	28 (20 - 36)	64 (45 - 84)	230[E] (130 - 340)
12–19	1	989	0	55 (49 - 62)	14 (13 - 16)	49 (41 - 57)	100 (91 - 120)	420 (350 - 480)
12–19	2	510	0	39 (33 - 45)	11 (9.3 - 12)	33 (27 - 40)	74 (55 - 93)	310 (200 - 410)
20–39	1	728	0	65 (56 - 75)	14 (13 - 16)	54 (45 - 64)	130 (100 - 160)	F
20–39	2	357	0	42 (30 - 60)	10 (6.9 - 13)	34[E] (16 - 52)	110[E] (61 - 160)	F
40–59[b]	1							
40–59	2	358	0	45 (31 - 64)	9.7[E] (4.9 - 15)	39 (28 - 51)	85[E] (33 - 140)	F
60–79[b]	1							
60–79	2	290	0	57 (46 - 70)	14 (9.9 - 18)	47 (32 - 62)	100 (77 - 130)	560[E] (220 - 900)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.4.6

Mono-ethyl phthalate (MEP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1278	0	39 (31 - 49)	9.4 (7.7 - 11)	31 (23 - 38)	96 (65 - 130)	390^{E} (<LOD - 600)
Males, 6–11	1	523	0.19	35 (28 - 44)	12 (10 - 14)	29 (24 - 34)	55^{E} (34 - 76)	200^{E} (120 - 270)
Males, 6–11	2	261	0	28 (21 - 38)	10 (8.7 - 12)	25^{E} (15 - 34)	60^{E} (30 - 91)	140^{E} (78 - 190)
Males, 12–19	1	505	0	47 (40 - 55)	13 (9.3 - 16)	41 (34 - 49)	91 (67 - 120)	420 (270 - 560)
Males, 12–19	2	255	0	32 (26 - 40)	9.5 (8.1 - 11)	28 (20 - 37)	56 (38 - 73)	260^{E} (110 - 410)
Males, 20–39	1	364	0	63 (50 - 80)	12 (10 - 15)	53 (36 - 71)	140 (90 - 190)	F
Males, 20–39	2	167	0	42^{E} (26 - 67)	8.9^{E} (4.8 - 13)	F	130^{E} (60 - 210)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	0	41^{E} (26 - 65)	9.0^{E} (5.2 - 13)	31^{E} (12 - 50)	100^{E} (35 - 170)	x
Males, 60–79[c]	1							
Males, 60–79	2	142	0	43 (33 - 56)	11 (8.3 - 14)	35^{E} (20 - 49)	86 (56 - 120)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1273	0	50 (41 - 61)	14 (11 - 17)	44 (38 - 49)	85 (59 - 110)	F
Females, 6–11	1	511	0	45 (38 - 54)	16 (14 - 19)	38 (32 - 43)	70 (56 - 84)	F
Females, 6–11	2	253	0	41 (31 - 54)	12^{E} (7.7 - 17)	34 (24 - 44)	72^{E} (35 - 110)	260^{E} (130 - 400)
Females, 12–19	1	484	0	66 (57 - 76)	17 (15 - 19)	58 (46 - 70)	120 (82 - 160)	420 (300 - 530)
Females, 12–19	2	255	0	48 (38 - 60)	13 (<LOD - 17)	39 (29 - 49)	96 (67 - 130)	F
Females, 20–39	1	364	0	66 (53 - 82)	16 (13 - 18)	57 (41 - 74)	130 (95 - 160)	F
Females, 20–39	2	190	0	43^{E} (29 - 65)	13 (8.7 - 16)	41 (26 - 55)	80^{E} (31 - 130)	x
Females, 40–59[c]	1							
Females, 40–59	2	164	0	49^{E} (33 - 74)	14^{E} (<LOD - 22)	44 (33 - 55)	F	x
Females, 60–79[c]	1							
Females, 60–79	2	148	0	73 (52 - 100)	24 (20 - 29)	61 (40 - 82)	110 (81 - 140)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.5 MONO-ISOBUTYL PHTHALATE (MiBP)

Table 15.5.1

Mono-isobutyl phthalate (MiBP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2547	0.04	14 (12 - 16)	3.5 (2.7 - 4.4)	14 (12 - 16)	25 (20 - 30)	64 (50 - 79)
3–5	2	517	0	22 (19 - 25)	6.9 (5.0 - 8.9)	22 (18 - 26)	39 (33 - 44)	96 (68 - 120)
6–11	2	515	0	22 (18 - 27)	6.6 (5.0 - 8.3)	22 (18 - 26)	39 (32 - 46)	120[E] (67 - 160)
12–19	2	508	0	18 (16 - 21)	5.6 (4.0 - 7.2)	18 (16 - 20)	31 (28 - 35)	83[E] (38 - 130)
20–39	2	359	0.28	15 (13 - 18)	3.2[E] (1.7 - 4.7)	18 (15 - 20)	27 (18 - 36)	65 (49 - 81)
40–59	2	359	0	12 (9.6 - 15)	3.0[E] (1.4 - 4.7)	12 (8.3 - 15)	21 (17 - 25)	47[E] (18 - 75)
60–79	2	289	0	9.7 (7.6 - 12)	2.4[E] (1.4 - 3.4)	9.3 (7.5 - 11)	16 (11 - 20)	42 (29 - 55)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.5.2

Mono-isobutyl phthalate (MiBP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1275	0	14 (12 - 17)	3.7[E] (2.2 - 5.1)	15 (12 - 17)	26 (19 - 33)	67 (43 - 90)
Males, 6–11	2	261	0	23 (16 - 32)	6.5 (5.0 - 8.0)	22[E] (13 - 30)	40[E] (20 - 60)	130[E] (54 - 210)
Males, 12–19	2	256	0	18 (16 - 21)	6.7 (4.5 - 8.8)	17 (14 - 20)	29 (25 - 33)	62 (40 - 84)
Males, 20–39	2	168	0	16 (12 - 21)	3.7[E] (1.5 - 6.0)	18 (14 - 21)	34[E] (20 - 49)	x
Males, 40–59	2	193	0	12 (8.4 - 17)	2.3[E] (0.69 - 3.9)	12[E] (7.0 - 17)	22[E] (14 - 31)	x
Males, 60–79	2	141	0	10 (7.9 - 14)	2.9[E] (0.89 - 4.9)	10 (7.7 - 13)	16 (11 - 21)	x
Females, Total 3–79	2	1272	0.08	13 (11 - 15)	3.5 (2.5 - 4.5)	13 (11 - 16)	23 (20 - 27)	58 (42 - 73)
Females, 6–11	2	254	0	22 (18 - 27)	6.9[E] (3.5 - 10)	22 (17 - 27)	36 (30 - 43)	95[E] (56 - 130)
Females, 12–19	2	252	0	19 (14 - 25)	4.7[E] (2.7 - 6.7)	18 (14 - 23)	34 (27 - 40)	F
Females, 20–39	2	191	0.52	14 (11 - 17)	2.7[E] (1.4 - 4.0)	18 (12 - 23)	25 (18 - 32)	x
Females, 40–59	2	166	0	12 (9.3 - 15)	4.0[E] (1.6 - 6.4)	11 (7.7 - 15)	20 (15 - 25)	x
Females, 60–79	2	148	0	8.9 (6.6 - 12)	2.1[E] (1.3 - 3.0)	8.4 (6.4 - 10)	16[E] (8.5 - 23)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.5.3

Mono-isobutyl phthalate (MiBP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2537	0.04	13 (12 - 15)	5.4 (4.7 - 6.1)	13 (12 - 14)	21 (18 - 24)	48 (38 - 59)
3–5	2	516	0	37 (33 - 42)	16 (13 - 19)	34 (30 - 38)	55 (42 - 68)	120 (89 - 150)
6–11	2	513	0	25 (22 - 30)	11 (8.9 - 14)	23 (20 - 27)	37 (28 - 45)	94^{E} (41 - 150)
12–19	2	506	0	14 (12 - 16)	7.1 (6.1 - 8.1)	13 (11 - 14)	19 (15 - 23)	41^{E} (16 - 65)
20–39	2	357	0.28	13 (12 - 14)	5.5 (4.3 - 6.6)	13 (12 - 14)	18 (14 - 23)	44^{E} (26 - 62)
40–59	2	357	0	12 (11 - 14)	5.4 (4.6 - 6.2)	12 (10 - 14)	19 (15 - 22)	32 (22 - 42)
60–79	2	288	0	11 (8.9 - 14)	4.5 (2.9 - 6.0)	11 (7.8 - 14)	19 (13 - 24)	37 (27 - 47)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.5.4

Mono-isobutyl phthalate (MiBP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1271	0	12 (11 - 14)	4.9 (3.9 - 5.9)	11 (10 - 13)	18 (14 - 21)	46 (34 - 58)
Males, 6–11	2	260	0	26 (20 - 33)	9.9 (6.7 - 13)	22 (16 - 29)	38^{E} (21 - 54)	130^{E} (43 - 210)
Males, 12–19	2	255	0	13 (12 - 15)	6.2 (4.7 - 7.8)	12 (10 - 14)	18 (13 - 23)	38 (30 - 46)
Males, 20–39	2	167	0	12 (10 - 14)	5.1 (3.3 - 6.9)	11 (9.1 - 13)	16 (11 - 21)	x
Males, 40–59	2	193	0	10 (8.3 - 12)	4.7 (3.5 - 5.8)	10 (8.0 - 12)	16 (11 - 20)	x
Males, 60–79	2	141	0	9.8 (7.6 - 13)	3.8^{E} (1.3 - 6.3)	9.8 (7.4 - 12)	15 (12 - 19)	x
Females, Total 3–79	2	1266	0.08	15 (13 - 17)	6.2 (5.2 - 7.3)	14 (13 - 16)	22 (19 - 26)	49 (33 - 65)
Females, 6–11	2	253	0	25 (21 - 30)	12 (9.7 - 15)	24 (19 - 30)	33 (26 - 41)	78 (55 - 100)
Females, 12–19	2	251	0	15 (12 - 19)	7.4 (6.6 - 8.3)	14 (11 - 16)	21 (16 - 26)	F
Females, 20–39	2	190	0.53	14 (12 - 17)	5.5 (4.2 - 6.7)	14 (12 - 16)	20 (13 - 27)	x
Females, 40–59	2	164	0	14 (12 - 17)	6.3 (4.9 - 7.8)	14 (11 - 17)	21 (18 - 25)	x
Females, 60–79	2	147	0	13 (9.9 - 16)	5.4 (3.6 - 7.3)	12^{E} (7.7 - 17)	24 (16 - 31)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.6 MONO-ISONONYL PHTHALATE (MiNP)

Table 15.6.1

Mono-isononyl phthalate (MiNP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3234	99.35	—	<LOD	<LOD	<LOD	<LOD
Total, 6–49	2	1604	99.25	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–49	1	1628	99.51	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–49	2	807	99.13	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–49	1	1606	99.19	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–49	2	797	99.37	—	<LOD	<LOD	<LOD	<LOD

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 15.6.2

Mono-isononyl phthalate (MiNP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2556	99.30	—	<LOD	<LOD	<LOD	<LOD
3–5[b]	1							
3–5	2	522	99.04	—	<LOD	<LOD	<LOD	<LOD
6–11	1	1036	99.42	—	<LOD	<LOD	<LOD	<LOD
6–11	2	514	99.42	—	<LOD	<LOD	<LOD	<LOD
12–19	1	991	99.19	—	<LOD	<LOD	<LOD	<LOD
12–19	2	511	99.41	—	<LOD	<LOD	<LOD	<LOD
20–39	1	730	99.86	—	<LOD	<LOD	<LOD	<LOD
20–39	2	358	98.60	—	<LOD	<LOD	<LOD	<LOD
40–59[b]	1							
40–59	2	360	99.72	—	<LOD	<LOD	<LOD	<LOD
60–79[b]	1							
60–79	2	291	99.66	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

Table 15.6.3

Mono-isononyl phthalate (MiNP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1280	99.45	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	1	524	99.24	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	261	98.85	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	1	506	99.41	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	99.61	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	1	366	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	168	98.21	—	<LOD	<LOD	<LOD	x
Males, 40–59[c]	1							
Males, 40–59	2	194	100	—	<LOD	<LOD	<LOD	x
Males, 60–79[c]	1							
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1276	99.14	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	1	512	99.61	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	253	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	1	485	98.97	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	256	99.22	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	1	364	99.73	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	190	98.95	—	<LOD	<LOD	<LOD	x
Females, 40–59[c]	1							
Females, 40–59	2	166	99.40	—	<LOD	<LOD	<LOD	x
Females, 60–79[c]	1							
Females, 60–79	2	149	99.33	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.6.4

Mono-isononyl phthalate (MiNP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3226	99.60	—	<LOD	<LOD	<LOD	<LOD
Total, 6–49	2	1596	99.69	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–49	1	1622	99.88	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–49	2	804	99.76	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–49	1	1604	99.31	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–49	2	792	99.61	—	<LOD	<LOD	<LOD	<LOD

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 15.6.5

Mono-isononyl phthalate (MiNP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2546	99.69	—	<LOD	<LOD	<LOD	<LOD
3–5[b]	1							
3–5	2	521	99.23	—	<LOD	<LOD	<LOD	<LOD
6–11	1	1033	99.71	—	<LOD	<LOD	<LOD	<LOD
6–11	2	512	99.80	—	<LOD	<LOD	<LOD	<LOD
12–19	1	989	99.39	—	<LOD	<LOD	<LOD	<LOD
12–19	2	509	99.80	—	<LOD	<LOD	<LOD	<LOD
20–39	1	728	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	356	99.16	—	<LOD	<LOD	<LOD	<LOD
40–59[b]	1							
40–59	2	358	100	—	<LOD	<LOD	<LOD	<LOD
60–79[b]	1							
60–79	2	290	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

Table 15.6.6

Mono-isononyl phthalate (MiNP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1276	99.76	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	1	522	99.62	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	260	99.23	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	1	505	99.60	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	1	364	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	167	98.80	—	<LOD	<LOD	<LOD	x
Males, 40–59[c]	1							
Males, 40–59	2	194	100	—	<LOD	<LOD	<LOD	x
Males, 60–79[c]	1							
Males, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1270	99.61	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	1	511	99.80	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	252	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	1	484	99.17	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	255	99.61	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	1	364	99.73	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	99.47	—	<LOD	<LOD	<LOD	x
Females, 40–59[c]	1							
Females, 40–59	2	164	100	—	<LOD	<LOD	<LOD	x
Females, 60–79[c]	1							
Females, 60–79	2	148	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.7 MONO-METHYL PHTHALATE (MMP)

Table 15.7.1

Mono-methyl phthalate (MMP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3235	73.42	—	<LOD	<LOD	<LOD	9.7 (8.2 - 11)
Total, 6–49	2	1607	56.94	—	<LOD	<LOD	<LOD (<LOD - 5.6)	17 (14 - 21)
Males, Total 6–49	1	1629	71.15	—	<LOD	<LOD	<LOD	9.8^{E} (<LOD - 15)
Males, Total 6–49	2	808	55.45	—	<LOD	<LOD	5.6 (<LOD - 7.1)	17 (11 - 24)
Females, Total 6–49	1	1606	75.72	—	<LOD	<LOD	<LOD	9.6 (8.9 - 10)
Females, Total 6–49	2	799	58.45	—	<LOD	<LOD	<LOD	17^{E} (7.4 - 27)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.7.2

Mono-methyl phthalate (MMP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2559	58.38	—	<LOD	<LOD	<LOD	17^{E} (9.3 - 25)
3–5[b]	1							
3–5	2	523	43.98	—	<LOD	<LOD (<LOD - 5.9)	8.4 (7.5 - 9.3)	F
6–11	1	1037	64.90	—	<LOD	<LOD	7.0 (<LOD - 9.2)	25 (17 - 32)
6–11	2	515	42.33	—	<LOD	<LOD (<LOD - 6.5)	8.7^{E} (<LOD - 14)	34^{E} (19 - 49)
12–19	1	991	67.81	—	<LOD	<LOD	5.9 (<LOD - 7.3)	11^{E} (<LOD - 18)
12–19	2	512	53.91	—	<LOD	<LOD	6.4 (5.5 - 7.3)	18 (12 - 24)
20–39	1	730	83.97	—	<LOD	<LOD	<LOD	9.4 (8.1 - 11)
20–39	2	359	70.75	—	<LOD	<LOD	<LOD	F
40–59[b]	1							
40–59	2	360	78.33	—	<LOD	<LOD	<LOD	F
60–79[b]	1							
60–79	2	290	80.69	—	<LOD	<LOD	<LOD	8.5 (7.1 - 9.8)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.7.3

Mono-methyl phthalate (MMP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1280	56.02	—	<LOD	<LOD	5.3 (<LOD - 7.0)	F
Males, 6–11	1	525	63.81	—	<LOD	<LOD	6.9[E] (<LOD - 10)	27[E] (17 - 37)
Males, 6–11	2	261	44.83	—	<LOD	5.0 (<LOD - 6.7)	F	31[E] (19 - 43)
Males, 12–19	1	506	65.61	—	<LOD	<LOD	5.6 (<LOD - 7.5)	9.7 (9.4 - 10)
Males, 12–19	2	256	53.13	—	<LOD	<LOD	6.4 (5.5 - 7.3)	F
Males, 20–39	1	366	80.60	—	<LOD	<LOD	<LOD	9.6[E] (5.9 - 13)
Males, 20–39	2	168	64.29	—	<LOD	<LOD	<LOD[E] (<LOD - 6.6)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	73.20	—	<LOD	<LOD	<LOD	x
Males, 60–79[c]	1							
Males, 60–79	2	141	73.05	—	<LOD	<LOD	F	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1279	60.75	—	<LOD	<LOD	<LOD	F
Females, 6–11	1	512	66.02	—	<LOD	<LOD	7.1 (5.0 - 9.3)	23[E] (13 - 32)
Females, 6–11	2	254	39.76	7.7[E] (5.2 - 12)	<LOD	<LOD[E] (<LOD - 6.9)	F	F
Females, 12–19	1	485	70.10	—	<LOD	<LOD	6.2 (<LOD - 8.0)	18[E] (8.8 - 27)
Females, 12–19	2	256	54.69	—	<LOD	<LOD	6.3 (<LOD - 8.1)	19[E] (12 - 26)
Females, 20–39	1	364	87.36	—	<LOD	<LOD	<LOD	9.2[E] (5.3 - 13)
Females, 20–39	2	191	76.44	—	<LOD	<LOD	<LOD	x
Females, 40–59[c]	1							
Females, 40–59	2	166	84.34	—	<LOD	<LOD	<LOD	x
Females, 60–79[c]	1							
Females, 60–79	2	149	87.92	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.7.4

Mono-methyl phthalate (MMP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3227	73.58	—	<LOD	<LOD	<LOD	18 (16 - 20)
Total, 6–49	2	1599	58.61	—	<LOD	<LOD	<LOD (<LOD - 5.9)	16 (11 - 20)
Males, Total 6–49	1	1623	71.37	—	<LOD	<LOD	<LOD	16 (<LOD - 19)
Males, Total 6–49	2	805	56.19	—	<LOD	<LOD	5.1 (<LOD - 6.0)	15[E] (7.9 - 23)
Females, Total 6–49	1	1604	75.83	—	<LOD	<LOD	<LOD	20 (17 - 22)
Females, Total 6–49	2	794	61.04	—	<LOD	<LOD	<LOD	17[E] (9.7 - 24)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.7.5

Mono-methyl phthalate (MMP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2549	58.61	—	<LOD	<LOD	<LOD	17 (12 - 22)
3–5[b]	1							
3–5	2	522	44.06	—	<LOD	<LOD (<LOD - 9.8)	15 (12 - 19)	51[E] (22 - 80)
6–11	1	1034	65.09	—	<LOD	<LOD	11 (<LOD - 13)	37 (25 - 49)
6–11	2	513	42.50	—	<LOD	<LOD (<LOD - 7.7)	12 (<LOD - 16)	34[E] (16 - 52)
12–19	1	989	67.95	—	<LOD	<LOD	5.9 (<LOD - 6.6)	13 (<LOD - 15)
12–19	2	510	54.12	—	<LOD	<LOD	5.1 (4.0 - 6.1)	13 (10 - 15)
20–39	1	728	84.20	—	<LOD	<LOD	<LOD	17 (13 - 22)
20–39	2	357	71.15	—	<LOD	<LOD	<LOD	F
40–59[b]	1							
40–59	2	358	78.77	—	<LOD	<LOD	<LOD	F
60–79[b]	1							
60–79	2	289	80.97	—	<LOD	<LOD	<LOD	16 (12 - 21)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.7.6

Mono-methyl phthalate (MMP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1276	56.19	—	<LOD	<LOD	5.4 (<LOD - 6.4)	17[E] (<LOD - 28)
Males, 6–11	1	523	64.05	—	<LOD	<LOD	11 (<LOD - 14)	39[E] (21 - 57)
Males, 6–11	2	260	45.00	—	<LOD	6.3 (<LOD - 7.8)	12 (<LOD - 15)	31[E] (19 - 43)
Males, 12–19	1	505	65.74	—	<LOD	<LOD	5.1 (<LOD - 5.7)	12 (11 - 14)
Males, 12–19	2	255	53.33	—	<LOD	<LOD	4.2[E] (2.7 - 5.7)	13 (<LOD - 17)
Males, 20–39	1	364	81.04	—	<LOD	<LOD	<LOD	13[E] (7.6 - 19)
Males, 20–39	2	167	64.67	—	<LOD	<LOD	<LOD (<LOD - 5.5)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	73.20	—	<LOD	<LOD	<LOD	x
Males, 60–79[c]	1							
Males, 60–79	2	141	73.05	—	<LOD	<LOD	<LOD (<LOD - 6.5)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1273	61.04	—	<LOD	<LOD	<LOD	17 (<LOD - 21)
Females, 6–11	1	511	66.14	—	<LOD	<LOD	11 (8.7 - 13)	32 (22 - 43)
Females, 6–11	2	253	39.92	8.6[E] (5.9 - 12)	<LOD	<LOD (<LOD - 7.9)	14[E] (<LOD - 22)	F
Females, 12–19	1	484	70.25	—	<LOD	<LOD	6.8 (<LOD - 8.2)	16 (12 - 19)
Females, 12–19	2	255	54.90	—	<LOD	<LOD	5.5 (<LOD - 6.6)	13 (8.6 - 17)
Females, 20–39	1	364	87.36	—	<LOD	<LOD	<LOD	19 (13 - 24)
Females, 20–39	2	190	76.84	—	<LOD	<LOD	<LOD	x
Females, 40–59[c]	1							
Females, 40–59	2	164	85.37	—	<LOD	<LOD	<LOD	x
Females, 60–79[c]	1							
Females, 60–79	2	148	88.51	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.8 MONO-*n*-OCTYL PHTHALATE (MOP)

Table 15.8.1

Mono-*n*-octyl phthalate (MOP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3235	94.90	—	<LOD	<LOD	<LOD	<LOD^{E} (<LOD - 0.89)
Total, 6–49	2	1606	98.88	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–49	1	1629	94.84	—	<LOD	<LOD	<LOD	0.72^{E} (<LOD - 1.0)
Males, Total 6–49	2	808	98.64	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–49	1	1606	94.96	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–49	2	798	99.12	—	<LOD	<LOD	<LOD	<LOD

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.8.2

Mono-*n*-octyl phthalate (MOP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2558	98.51	—	<LOD	<LOD	<LOD	<LOD
3–5[b]	1							
3–5	2	523	97.13	—	<LOD	<LOD	<LOD	<LOD
6–11	1	1037	95.08	—	<LOD	<LOD	<LOD	<LOD
6–11	2	516	99.61	—	<LOD	<LOD	<LOD	<LOD
12–19	1	991	94.45	—	<LOD	<LOD	<LOD	<LOD
12–19	2	511	98.04	—	<LOD	<LOD	<LOD	<LOD
20–39	1	730	95.21	—	<LOD	<LOD	<LOD	0.71 (<LOD - 0.95)
20–39	2	358	98.88	—	<LOD	<LOD	<LOD	<LOD
40–59[b]	1							
40–59	2	360	99.17	—	<LOD	<LOD	<LOD	<LOD
60–79[b]	1							
60–79	2	290	98.62	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

Table 15.8.3

Mono-*n*-octyl phthalate (MOP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1280	98.36	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	1	525	94.67	—	<LOD	<LOD	<LOD	F
Males, 6–11	2	262	99.24	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	1	506	94.66	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	255	97.65	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	1	366	94.26	—	<LOD	<LOD	<LOD	0.93[E] (<LOD - 1.3)
Males, 20–39	2	168	98.81	—	<LOD	<LOD	<LOD	x
Males, 40–59[c]	1							
Males, 40–59	2	194	98.97	—	<LOD	<LOD	<LOD	x
Males, 60–79[c]	1							
Males, 60–79	2	141	98.58	—	<LOD	<LOD	<LOD	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1278	98.67	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	1	512	95.51	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	1	485	94.23	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	256	98.44	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	1	364	96.15	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	190	98.95	—	<LOD	<LOD	<LOD	x
Females, 40–59[c]	1							
Females, 40–59	2	166	99.40	—	<LOD	<LOD	<LOD	x
Females, 60–79[c]	1							
Females, 60–79	2	149	98.66	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.8.4

Mono-*n*-octyl phthalate (MOP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3227	95.14	—	<LOD	<LOD	<LOD	<LOD (<LOD - 2.3)
Total, 6–49	2	1598	98.90	—	<LOD	<LOD	<LOD	<LOD
Males, Total 6–49	1	1623	95.20	—	<LOD	<LOD	<LOD	1.6 (<LOD - 2.0)
Males, Total 6–49	2	805	98.67	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–49	1	1604	95.08	—	<LOD	<LOD	<LOD	<LOD
Females, Total 6–49	2	793	99.14	—	<LOD	<LOD	<LOD	<LOD

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 15.8.5

Mono-*n*-octyl phthalate (MOP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2548	98.90	—	<LOD	<LOD	<LOD	<LOD
3–5[b]	1							
3–5	2	522	97.32	—	<LOD	<LOD	<LOD	<LOD
6–11	1	1034	95.36	—	<LOD	<LOD	<LOD	<LOD
6–11	2	514	100	—	<LOD	<LOD	<LOD	<LOD
12–19	1	989	94.64	—	<LOD	<LOD	<LOD	<LOD
12–19	2	509	98.43	—	<LOD	<LOD	<LOD	<LOD
20–39	1	728	95.47	—	<LOD	<LOD	<LOD	1.9 (<LOD - 2.3)
20–39	2	356	99.44	—	<LOD	<LOD	<LOD	<LOD
40–59[b]	1							
40–59	2	358	99.72	—	<LOD	<LOD	<LOD	<LOD
60–79[b]	1							
60–79	2	289	98.96	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

Table 15.8.6

Mono-*n*-octyl phthalate (MOP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1276	98.67	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	1	523	95.03	—	<LOD	<LOD	<LOD	<LOD (<LOD - 4.9)
Males, 6–11	2	261	99.62	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	1	505	94.85	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	98.03	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	1	364	94.78	—	<LOD	<LOD	<LOD	1.6[E] (<LOD - 2.2)
Males, 20–39	2	167	99.40	—	<LOD	<LOD	<LOD	x
Males, 40–59[c]	1							
Males, 40–59	2	194	98.97	—	<LOD	<LOD	<LOD	x
Males, 60–79[c]	1							
Males, 60–79	2	141	98.58	—	<LOD	<LOD	<LOD	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1272	99.14	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	1	511	95.69	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	253	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	1	484	94.42	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	255	98.82	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	1	364	96.15	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	189	99.47	—	<LOD	<LOD	<LOD	x
Females, 40–59[c]	1							
Females, 40–59	2	164	100	—	<LOD	<LOD	<LOD	x
Females, 60–79[c]	1							
Females, 60–79	2	148	99.32	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.9 MONO-3-CARBOXYPROPYL PHTHALATE (MCPP)

Table 15.9.1

Mono-3-carboxypropyl phthalate (MCPP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3235	7.36	1.5 (1.3 - 1.6)	F	1.7 (1.4 - 1.9)	3.5 (3.2 - 3.9)	9.7 (8.2 - 11)
Total, 6–49	2	1603	1.43	2.1 (1.8 - 2.4)	0.52 (0.35 - 0.70)	2.3 (1.9 - 2.7)	4.4 (3.9 - 4.9)	12 (9.1 - 14)
Males, Total 6–49	1	1629	6.02	1.6 (1.4 - 1.9)	F	1.9 (1.6 - 2.3)	3.8 (3.5 - 4.1)	9.9 (7.7 - 12)
Males, Total 6–49	2	808	0.62	2.2 (1.8 - 2.8)	0.56[E] (0.24 - 0.88)	2.3 (1.8 - 2.9)	4.6 (4.1 - 5.2)	13 (9.2 - 16)
Females, Total 6–49	1	1606	8.72	1.3 (1.2 - 1.5)	<LOD	1.5 (1.3 - 1.7)	3.2 (2.9 - 3.5)	9.2 (7.1 - 11)
Females, Total 6–49	2	795	2.26	2.0 (1.7 - 2.3)	0.51[E] (0.31 - 0.71)	2.2 (1.8 - 2.7)	4.0 (3.2 - 4.9)	9.0[E] (3.7 - 14)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 15.9.2

Mono-3-carboxypropyl phthalate (MCPP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2543	1.22	1.9 (1.7 - 2.1)	0.47 (0.38 - 0.57)	2.0 (1.7 - 2.2)	3.8 (3.5 - 4.2)	11 (9.0 - 12)
3–5[b]	1							
3–5	2	517	0.39	3.2 (2.8 - 3.7)	0.94 (0.63 - 1.2)	3.1 (2.6 - 3.6)	5.6 (4.3 - 6.8)	14[E] (8.5 - 19)
6–11	1	1037	3.18	2.7 (2.2 - 3.2)	0.69[E] (0.42 - 0.95)	3.1 (2.5 - 3.7)	5.4 (4.6 - 6.3)	12 (9.8 - 15)
6–11	2	515	0.78	3.3 (2.8 - 4.0)	1.0 (0.80 - 1.2)	3.4 (2.9 - 3.9)	5.5 (4.3 - 6.8)	15 (11 - 19)
12–19	1	991	5.25	2.2 (1.9 - 2.6)	0.40[E] (<LOD - 0.63)	2.6 (2.3 - 2.9)	4.2 (3.7 - 4.8)	11[E] (6.5 - 15)
12–19	2	509	0.79	2.6 (2.2 - 3.1)	0.65[E] (0.34 - 0.97)	2.5 (2.2 - 2.8)	4.7 (3.6 - 5.8)	16[E] (8.0 - 24)
20–39	1	730	11.37	1.3 (1.1 - 1.6)	F	1.5 (1.2 - 1.8)	3.1 (2.4 - 3.8)	8.4 (5.8 - 11)
20–39	2	359	1.95	1.9 (1.5 - 2.5)	0.49[E] (0.25 - 0.72)	2.0 (1.3 - 2.7)	4.4 (3.3 - 5.6)	10 (6.9 - 13)
40–59[b]	1							
40–59	2	359	3.06	1.6 (1.4 - 1.9)	0.45[E] (0.24 - 0.66)	1.8 (1.4 - 2.1)	2.9 (2.3 - 3.4)	8.7[E] (3.4 - 14)
60–79[b]	1							
60–79	2	284	1.06	1.5 (1.2 - 1.7)	0.41[E] (0.26 - 0.57)	1.5 (1.3 - 1.7)	2.7 (2.0 - 3.4)	8.7[E] (5.5 - 12)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.9.3

Mono-3-carboxypropyl phthalate (MCPP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1273	0.63	2.1 (1.8 - 2.5)	0.56 (0.38 - 0.73)	2.0 (1.6 - 2.4)	4.3 (3.7 - 5.0)	12 (9.0 - 15)
Males, 6–11	1	525	2.29	2.7 (2.0 - 3.6)	0.69[E] (0.25 - 1.1)	3.0 (2.1 - 3.9)	5.0 (3.5 - 6.5)	13 (9.3 - 16)
Males, 6–11	2	262	0.76	3.9 (3.1 - 4.9)	1.1 (0.80 - 1.4)	3.9 (2.7 - 5.1)	6.8[E] (3.9 - 9.8)	16 (12 - 20)
Males, 12–19	1	506	3.75	2.1 (1.7 - 2.7)	F	2.5 (1.9 - 3.1)	4.0 (3.4 - 4.6)	12[E] (5.5 - 18)
Males, 12–19	2	255	0	3.0 (2.5 - 3.7)	0.96[E] (0.47 - 1.5)	2.6 (2.2 - 3.0)	4.8 (3.6 - 6.0)	15 (11 - 19)
Males, 20–39	1	366	10.93	1.6 (1.3 - 2.0)	F	1.8 (1.3 - 2.3)	3.7 (3.1 - 4.4)	9.8[E] (5.4 - 14)
Males, 20–39	2	168	0.60	2.2 (1.6 - 3.0)	0.56[E] (0.24 - 0.87)	2.4[E] (1.3 - 3.5)	4.6 (3.5 - 5.6)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	1.55	1.7 (1.3 - 2.2)	F	1.6 (1.2 - 2.1)	2.9[E] (1.8 - 3.9)	x
Males, 60–79[c]	1							
Males, 60–79	2	137	0.73	1.7 (1.2 - 2.3)	0.54 (0.39 - 0.69)	1.5 (1.0 - 2.0)	2.9[E] (1.2 - 4.6)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1270	1.81	1.7 (1.5 - 2.0)	0.41 (0.28 - 0.55)	1.9 (1.6 - 2.2)	3.5 (3.0 - 4.0)	8.6 (6.4 - 11)
Females, 6–11	1	512	4.10	2.6 (2.3 - 3.1)	0.69 (0.48 - 0.89)	3.1 (2.4 - 3.7)	5.5 (4.7 - 6.3)	12 (9.4 - 15)
Females, 6–11	2	253	0.79	2.9 (2.2 - 3.6)	0.89[E] (0.49 - 1.3)	3.0 (2.2 - 3.7)	4.8 (4.0 - 5.6)	F
Females, 12–19	1	485	6.80	2.3 (1.9 - 2.7)	0.44[E] (<LOD - 0.71)	2.6 (2.3 - 3.0)	4.7 (3.4 - 6.0)	11 (6.9 - 14)
Females, 12–19	2	254	1.57	2.3 (1.7 - 3.1)	F	2.4 (1.8 - 3.0)	4.5 (3.0 - 6.0)	F
Females, 20–39	1	364	11.81	1.1 (0.89 - 1.4)	<LOD	1.2[E] (0.71 - 1.6)	2.5 (1.8 - 3.3)	7.7[E] (4.2 - 11)
Females, 20–39	2	191	3.14	1.7 (1.2 - 2.4)	0.32[E] (0.11 - 0.52)	1.7[E] (1.0 - 2.4)	4.1[E] (2.0 - 6.2)	x
Females, 40–59[c]	1							
Females, 40–59	2	165	4.85	1.6 (1.3 - 2.0)	0.46[E] (0.23 - 0.69)	1.9 (1.5 - 2.2)	2.9 (2.2 - 3.6)	x
Females, 60–79[c]	1							
Females, 60–79	2	147	1.36	1.3 (0.93 - 1.8)	0.25[E] (0.083 - 0.42)	1.5 (1.0 - 1.9)	2.5 (1.6 - 3.4)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.9.4

Mono-3-carboxypropyl phthalate (MCPP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3227	7.37	1.6 (1.5 - 1.7)	<LOD (<LOD - 0.53)	1.6 (1.5 - 1.7)	3.0 (2.8 - 3.2)	8.3 (6.5 - 10)
Total, 6–49	2	1595	1.22	1.8 (1.7 - 2.0)	0.64 (0.54 - 0.74)	1.8 (1.6 - 2.0)	3.4 (2.9 - 3.9)	9.9 (6.9 - 13)
Males, Total 6–49	1	1623	6.03	1.5 (1.4 - 1.6)	<LOD (<LOD - 0.53)	1.4 (1.3 - 1.6)	3.0 (2.5 - 3.5)	7.6 (5.4 - 9.8)
Males, Total 6–49	2	805	0.63	1.7 (1.5 - 2.1)	0.57 (0.46 - 0.68)	1.6 (1.3 - 1.9)	3.0 (2.3 - 3.7)	12[E] (6.4 - 17)
Females, Total 6–49	1	1604	8.72	1.7 (1.6 - 1.9)	<LOD	1.7 (1.5 - 1.8)	3.0 (2.7 - 3.2)	8.9 (6.2 - 12)
Females, Total 6–49	2	790	1.82	1.9 (1.7 - 2.2)	0.71 (0.58 - 0.83)	1.9 (1.7 - 2.1)	3.5 (3.0 - 4.0)	8.6 (6.0 - 11)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.9.5

Mono-3-carboxypropyl phthalate (MCPP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2533	1.22	1.9 (1.8 - 2.0)	0.66 (0.58 - 0.74)	1.8 (1.6 - 1.9)	3.4 (3.0 - 3.7)	9.2 (7.2 - 11)
3–5[b]	1							
3–5	2	516	0.39	5.6 (4.8 - 6.4)	2.5 (2.1 - 2.8)	5.5 (4.6 - 6.5)	7.7 (6.5 - 8.8)	21[E] (12 - 30)
6–11	1	1034	3.19	4.1 (3.6 - 4.6)	1.5 (1.2 - 1.7)	3.8 (3.4 - 4.3)	6.6 (5.7 - 7.5)	16 (11 - 20)
6–11	2	513	0.78	3.8 (3.4 - 4.3)	1.5 (1.1 - 1.9)	3.7 (3.3 - 4.1)	6.2 (5.2 - 7.2)	16 (11 - 20)
12–19	1	989	5.26	1.9 (1.7 - 2.1)	0.69 (<LOD - 0.81)	1.7 (1.6 - 1.9)	3.2 (2.6 - 3.8)	8.3 (5.3 - 11)
12–19	2	507	0.79	2.0 (1.8 - 2.3)	0.78 (0.59 - 0.98)	1.7 (1.5 - 2.0)	3.1 (2.6 - 3.5)	11[E] (4.2 - 18)
20–39	1	728	11.40	1.4 (1.3 - 1.6)	<LOD (<LOD - 0.55)	1.3 (1.1 - 1.5)	2.4 (2.0 - 2.8)	5.5[E] (3.5 - 7.5)
20–39	2	357	1.96	1.6 (1.4 - 1.9)	0.58 (0.43 - 0.73)	1.5 (1.2 - 1.8)	3.2 (2.2 - 4.1)	7.8[E] (3.4 - 12)
40–59[b]	1							
40–59	2	357	3.08	1.6 (1.5 - 1.8)	0.62 (0.50 - 0.74)	1.7 (1.4 - 2.0)	2.5 (2.0 - 3.0)	7.0[E] (3.6 - 10)
60–79[b]	1							
60–79	2	283	1.06	1.7 (1.5 - 1.9)	0.66[E] (0.38 - 0.95)	1.6 (1.4 - 1.9)	2.7 (2.1 - 3.3)	6.1[E] (3.2 - 9.0)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 15.9.6

Mono-3-carboxypropyl phthalate (MCPP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1269	0.63	1.8 (1.6 - 2.0)	0.59 (0.47 - 0.70)	1.7 (1.4 - 2.0)	3.0 (2.5 - 3.6)	10 (6.4 - 14)
Males, 6–11	1	523	2.29	4.1 (3.5 - 4.7)	1.6 (1.3 - 1.8)	3.8 (3.1 - 4.4)	6.2 (4.9 - 7.5)	15 (11 - 18)
Males, 6–11	2	261	0.77	4.4 (3.8 - 5.1)	1.8 (1.5 - 2.2)	4.6 (3.9 - 5.4)	6.6 (4.8 - 8.3)	16 (11 - 20)
Males, 12–19	1	505	3.76	1.8 (1.5 - 2.1)	0.63 (<LOD - 0.77)	1.6 (1.3 - 1.9)	3.1 (2.3 - 4.0)	8.4^E (4.6 - 12)
Males, 12–19	2	254	0	2.1 (1.8 - 2.6)	0.88 (0.66 - 1.1)	1.9 (1.5 - 2.4)	3.1 (2.6 - 3.7)	14^E (6.1 - 22)
Males, 20–39	1	364	10.99	1.3 (1.2 - 1.5)	<LOD (<LOD - 0.53)	1.2 (1.1 - 1.3)	2.5 (1.8 - 3.2)	5.5^E (3.1 - 7.9)
Males, 20–39	2	167	0.60	1.5 (1.2 - 2.0)	0.55^E (0.35 - 0.75)	1.3 (0.94 - 1.6)	2.4^E (1.5 - 3.3)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	1.55	1.4 (1.2 - 1.7)	0.53 (<LOD - 0.66)	1.4 (1.0 - 1.8)	2.2 (1.8 - 2.7)	x
Males, 60–79[c]	1							
Males, 60–79	2	137	0.73	1.6 (1.2 - 2.0)	0.66^E (0.26 - 1.1)	1.5 (1.0 - 2.0)	2.4^E (1.4 - 3.4)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1264	1.82	2.0 (1.7 - 2.2)	0.72 (0.61 - 0.83)	1.9 (1.7 - 2.2)	3.6 (3.1 - 4.1)	8.4 (6.9 - 10)
Females, 6–11	1	511	4.11	4.1 (3.6 - 4.6)	1.4 (1.1 - 1.6)	3.9 (3.4 - 4.4)	6.8 (6.0 - 7.7)	16^E (6.4 - 26)
Females, 6–11	2	252	0.79	3.3 (2.8 - 3.9)	1.3^E (0.81 - 1.8)	3.2 (2.9 - 3.5)	4.8 (3.6 - 5.9)	14^E (<LOD - 23)
Females, 12–19	1	484	6.82	2.0 (1.8 - 2.2)	0.78 (<LOD - 0.89)	1.8 (1.6 - 2.0)	3.3 (2.5 - 4.1)	8.2^E (4.0 - 12)
Females, 12–19	2	253	1.58	1.9 (1.5 - 2.3)	0.68 (0.48 - 0.88)	1.5 (1.3 - 1.8)	3.1 (2.2 - 3.9)	F
Females, 20–39	1	364	11.81	1.5 (1.2 - 1.7)	<LOD	1.4 (1.1 - 1.7)	2.4 (1.9 - 2.9)	F
Females, 20–39	2	190	3.16	1.7 (1.4 - 2.1)	0.66 (0.43 - 0.89)	1.7 (1.3 - 2.0)	3.5 (2.5 - 4.5)	x
Females, 40–59[c]	1							
Females, 40–59	2	163	4.91	1.9 (1.5 - 2.3)	0.81 (0.64 - 0.98)	2.0 (1.6 - 2.5)	3.2^E (1.8 - 4.5)	x
Females, 60–79[c]	1							
Females, 60–79	2	146	1.37	1.8 (1.4 - 2.3)	0.65^E (0.40 - 0.90)	1.7 (1.2 - 2.2)	2.9^E (1.6 - 4.2)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.10 MONO-2-ETHYLHEXYL PHTHALATE (MEHP)

Table 15.10.1

Mono-2-ethylhexyl phthalate (MEHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3235	0.34	3.6 (3.2 - 4.0)	0.85 (0.72 - 0.97)	3.4 (2.9 - 4.0)	7.1 (6.2 - 7.9)	24[E] (15 - 33)
Total, 6–49	2	1570	0.32	2.1 (1.9 - 2.4)	0.58 (0.43 - 0.73)	2.2 (1.9 - 2.4)	4.0 (3.4 - 4.7)	9.3 (7.5 - 11)
Males, Total 6–49	1	1629	0.18	4.1 (3.5 - 4.7)	0.88 (0.67 - 1.1)	3.9 (3.4 - 4.4)	7.8 (6.5 - 9.2)	F
Males, Total 6–49	2	792	0.25	2.3 (1.9 - 2.8)	0.65[E] (0.40 - 0.89)	2.4 (2.0 - 2.8)	4.4 (3.8 - 5.0)	11[E] (6.2 - 16)
Females, Total 6–49	1	1606	0.50	3.2 (2.8 - 3.7)	0.80 (0.57 - 1.0)	2.9 (2.6 - 3.3)	6.5 (5.5 - 7.5)	21[E] (13 - 30)
Females, Total 6–49	2	778	0.39	1.9 (1.7 - 2.1)	0.56 (0.39 - 0.73)	1.9 (1.5 - 2.4)	3.4 (2.7 - 4.2)	8.8 (7.2 - 10)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 15.10.2

Mono-2-ethylhexyl phthalate (MEHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2498	0.60	1.9 (1.7 - 2.1)	0.55 (0.44 - 0.66)	1.9 (1.6 - 2.1)	3.4 (2.8 - 4.0)	9.0 (7.8 - 10)
3–5[b]	1							
3–5	2	512	0.39	2.7 (2.4 - 3.2)	0.94 (0.77 - 1.1)	2.7 (2.3 - 3.1)	4.7 (3.9 - 5.5)	F
6–11	1	1037	0	3.3 (2.9 - 3.8)	0.90 (0.74 - 1.1)	3.3 (2.7 - 3.8)	6.3 (5.6 - 7.0)	18 (14 - 21)
6–11	2	508	0	2.7 (2.3 - 3.1)	0.85[E] (0.53 - 1.2)	2.5 (2.1 - 2.9)	4.8 (4.1 - 5.4)	11 (8.3 - 14)
12–19	1	991	0.81	3.5 (2.8 - 4.3)	0.84 (0.64 - 1.0)	3.2 (2.5 - 3.9)	7.0 (5.7 - 8.2)	23[E] (6.6 - 40)
12–19	2	501	0.60	2.4 (2.0 - 2.8)	0.64 (0.52 - 0.76)	2.4 (2.0 - 2.8)	4.3 (3.6 - 4.9)	13[E] (7.7 - 18)
20–39	1	730	0.14	4.0 (3.5 - 4.5)	0.99 (0.79 - 1.2)	3.9 (3.2 - 4.6)	7.7 (6.3 - 9.0)	23[E] (12 - 34)
20–39	2	349	0.29	1.9 (1.6 - 2.3)	0.44[E] (0.19 - 0.70)	1.9 (1.5 - 2.4)	3.4 (2.3 - 4.6)	8.8[E] (4.9 - 13)
40–59[b]	1							
40–59	2	349	1.15	1.9 (1.5 - 2.2)	0.63 (0.55 - 0.72)	1.9 (1.4 - 2.3)	3.1 (2.1 - 4.0)	9.0[E] (4.8 - 13)
60–79[b]	1							
60–79	2	279	1.79	1.3 (1.1 - 1.5)	0.44 (0.30 - 0.59)	1.2 (0.96 - 1.5)	2.2 (1.6 - 2.8)	7.1[E] (4.2 - 9.9)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.10.3

Mono-2-ethylhexyl phthalate (MEHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1253	0.56	2.1 (1.7 - 2.5)	0.58 (0.39 - 0.76)	2.2 (1.8 - 2.5)	4.1 (3.3 - 4.8)	11 (7.6 - 14)
Males, 6–11	1	525	0	3.5 (3.0 - 4.2)	0.89[E] (0.55 - 1.2)	3.8 (3.1 - 4.6)	6.7 (5.7 - 7.7)	17 (12 - 22)
Males, 6–11	2	257	0	2.9 (2.4 - 3.6)	0.83[E] (0.32 - 1.3)	2.6[E] (1.7 - 3.6)	5.3 (3.5 - 7.1)	12 (8.7 - 14)
Males, 12–19	1	506	0.59	3.2 (2.7 - 3.9)	0.84 (0.58 - 1.1)	2.9 (2.3 - 3.6)	5.9 (4.7 - 7.2)	F
Males, 12–19	2	250	0.40	2.4 (2.1 - 2.9)	0.64[E] (0.39 - 0.88)	2.4 (2.0 - 2.8)	4.2 (3.3 - 5.2)	13[E] (5.5 - 20)
Males, 20–39	1	366	0	4.7 (4.0 - 5.5)	1.2 (0.87 - 1.5)	4.7 (3.7 - 5.7)	9.1 (7.4 - 11)	22[E] (13 - 32)
Males, 20–39	2	165	0	2.4 (1.8 - 3.2)	F	2.7 (2.2 - 3.2)	4.5[E] (2.5 - 6.4)	x
Males, 40–59[c]	1							
Males, 40–59	2	189	1.59	1.9 (1.5 - 2.5)	0.64 (0.52 - 0.76)	1.8 (1.2 - 2.4)	4.0[E] (2.3 - 5.6)	x
Males, 60–79[c]	1							
Males, 60–79	2	137	2.19	1.3 (1.0 - 1.8)	0.37 (0.26 - 0.47)	1.2 (0.83 - 1.6)	2.4 (1.7 - 3.2)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1245	0.64	1.7 (1.5 - 1.9)	0.55 (0.41 - 0.69)	1.7 (1.3 - 2.1)	2.9 (2.5 - 3.2)	7.9 (6.5 - 9.3)
Females, 6–11	1	512	0	3.1 (2.7 - 3.6)	0.91 (0.72 - 1.1)	2.9 (2.3 - 3.5)	5.6 (4.7 - 6.5)	18 (13 - 22)
Females, 6–11	2	251	0	2.5 (2.1 - 2.9)	0.86[E] (0.51 - 1.2)	2.3 (1.8 - 2.8)	4.6 (3.7 - 5.5)	8.9[E] (3.4 - 14)
Females, 12–19	1	485	1.03	3.8 (2.7 - 5.2)	0.83[E] (0.52 - 1.1)	3.6 (2.5 - 4.7)	7.7 (5.9 - 9.6)	30[E] (11 - 49)
Females, 12–19	2	251	0.80	2.3 (1.8 - 2.9)	0.63[E] (0.39 - 0.86)	2.5 (1.9 - 3.1)	4.4 (3.7 - 5.2)	11[E] (6.8 - 15)
Females, 20–39	1	364	0.27	3.4 (2.9 - 3.9)	0.89 (0.60 - 1.2)	3.0 (2.1 - 4.0)	6.1 (4.3 - 7.8)	26[E] (11 - 42)
Females, 20–39	2	184	0.54	1.5 (1.2 - 1.9)	0.42[E] (0.22 - 0.61)	1.4[E] (0.84 - 1.9)	2.6 (1.9 - 3.3)	x
Females, 40–59[c]	1							
Females, 40–59	2	160	0.63	1.8 (1.5 - 2.1)	0.63 (0.47 - 0.80)	1.9 (1.3 - 2.5)	2.7 (2.3 - 3.1)	x
Females, 60–79[c]	1							
Females, 60–79	2	142	1.41	1.2 (1.0 - 1.5)	0.45[E] (0.23 - 0.67)	1.2 (0.92 - 1.5)	2.1 (1.5 - 2.7)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.10.4

Mono-2-ethylhexyl phthalate (MEHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3227	0.34	4.0 (3.5 - 4.5)	1.1 (0.95 - 1.3)	3.5 (3.2 - 3.9)	6.9 (6.0 - 7.7)	22 (14 - 29)
Total, 6–49	2	1563	0.60	1.8 (1.6 - 2.0)	0.68 (0.52 - 0.85)	1.7 (1.4 - 1.9)	2.9 (2.4 - 3.3)	8.3 (6.2 - 10)
Males, Total 6–49	1	1623	0.18	3.8 (3.4 - 4.3)	1.1 (0.90 - 1.3)	3.4 (3.0 - 3.8)	6.4 (5.3 - 7.6)	21[E] (9.9 - 31)
Males, Total 6–49	2	789	0.56	1.8 (1.5 - 2.1)	0.66 (0.50 - 0.82)	1.7 (1.4 - 2.0)	2.8 (2.3 - 3.3)	9.2[E] (5.5 - 13)
Females, Total 6–49	1	1604	0.50	4.2 (3.6 - 5.0)	1.3 (0.88 - 1.6)	3.7 (2.9 - 4.4)	7.2 (6.0 - 8.5)	23 (15 - 31)
Females, Total 6–49	2	774	0.65	1.8 (1.6 - 2.1)	0.75 (0.51 - 0.99)	1.7 (1.3 - 2.1)	2.9 (2.3 - 3.5)	7.6 (5.3 - 9.9)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.10.5

Mono-2-ethylhexyl phthalate (MEHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2489	0.60	1.8 (1.7 - 2.0)	0.65 (0.52 - 0.77)	1.8 (1.6 - 1.9)	3.0 (2.6 - 3.4)	8.8 (7.3 - 10)
3–5[b]	1							
3–5	2	511	0.39	4.7 (4.1 - 5.4)	1.8 (1.4 - 2.3)	4.5 (4.0 - 5.0)	7.3 (5.3 - 9.2)	19[E] (12 - 26)
6–11	1	1034	0	5.1 (4.5 - 5.7)	1.8 (1.5 - 2.0)	4.7 (4.3 - 5.2)	8.0 (6.9 - 9.0)	22 (18 - 25)
6–11	2	506	0	3.1 (2.7 - 3.6)	1.2 (0.94 - 1.4)	2.9 (2.4 - 3.3)	5.4 (4.1 - 6.6)	11 (8.6 - 14)
12–19	1	989	0.81	3.0 (2.4 - 3.8)	0.82 (0.62 - 1.0)	2.7 (2.3 - 3.1)	5.5 (3.9 - 7.0)	F
12–19	2	499	0.60	1.8 (1.6 - 2.0)	0.64 (0.56 - 0.72)	1.8 (1.6 - 2.1)	2.9 (2.5 - 3.4)	6.4[E] (3.0 - 9.7)
20–39	1	728	0.14	4.2 (3.7 - 4.8)	1.3 (0.93 - 1.6)	3.7 (3.0 - 4.3)	6.9 (5.7 - 8.0)	21[E] (13 - 30)
20–39	2	347	0.29	1.6 (1.3 - 1.9)	0.65[E] (0.40 - 0.90)	1.5 (1.2 - 1.8)	2.5 (2.0 - 3.1)	6.7[E] (3.5 - 10)
40–59[b]	1							
40–59	2	348	1.15	1.8 (1.6 - 2.1)	0.58[E] (0.33 - 0.83)	1.8 (1.5 - 2.1)	2.8 (2.2 - 3.3)	7.6[E] (3.7 - 11)
60–79[b]	1							
60–79	2	278	1.80	1.5 (1.3 - 1.7)	0.49[E] (0.30 - 0.68)	1.4 (1.2 - 1.6)	2.4 (1.6 - 3.2)	7.3[E] (4.4 - 10)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.10.6

Mono-2-ethylhexyl phthalate (MEHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1249	0.56	1.7 (1.5 - 2.0)	0.58 (0.45 - 0.70)	1.6 (1.4 - 1.9)	2.9 (2.4 - 3.3)	9.3 (6.2 - 12)
Males, 6–11	1	523	0	5.4 (4.9 - 5.9)	1.9 (1.7 - 2.1)	4.9 (4.3 - 5.5)	9.0 (7.2 - 11)	22 (18 - 26)
Males, 6–11	2	256	0	3.3 (2.7 - 4.1)	1.1 (0.74 - 1.5)	2.9 (1.9 - 3.9)	5.9 (4.1 - 7.7)	11 (8.6 - 14)
Males, 12–19	1	505	0.59	2.7 (2.1 - 3.4)	0.69 (0.51 - 0.88)	2.6 (2.2 - 3.0)	4.8 (3.6 - 6.1)	F
Males, 12–19	2	249	0.40	1.7 (1.5 - 2.0)	0.64 (0.55 - 0.72)	1.8 (1.4 - 2.1)	2.9 (2.4 - 3.4)	8.1[E] (4.5 - 12)
Males, 20–39	1	364	0	4.0 (3.5 - 4.6)	1.1 (0.75 - 1.5)	3.7 (3.1 - 4.3)	6.4 (5.2 - 7.7)	16[E] (9.1 - 24)
Males, 20–39	2	164	0	1.7 (1.3 - 2.2)	0.67[E] (<LOD - 1.0)	1.6 (1.2 - 1.9)	2.5 (1.8 - 3.3)	x
Males, 40–59[c]	1							
Males, 40–59	2	189	1.59	1.6 (1.3 - 2.0)	0.53 (0.42 - 0.63)	1.7 (1.3 - 2.2)	2.4 (1.9 - 3.0)	x
Males, 60–79[c]	1							
Males, 60–79	2	137	2.19	1.2 (0.98 - 1.6)	0.40[E] (0.17 - 0.63)	1.2 (0.99 - 1.4)	2.0[E] (0.97 - 3.0)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1240	0.65	1.9 (1.7 - 2.2)	0.75 (0.59 - 0.91)	1.9 (1.6 - 2.1)	3.2 (2.6 - 3.8)	7.9 (6.3 - 9.6)
Females, 6–11	1	511	0	4.8 (4.0 - 5.7)	1.6 (1.3 - 1.9)	4.5 (3.8 - 5.2)	7.6 (6.6 - 8.6)	22 (15 - 28)
Females, 6–11	2	250	0	2.9 (2.5 - 3.3)	1.2 (0.99 - 1.4)	2.8 (2.4 - 3.3)	4.5 (3.5 - 5.5)	9.3 (7.5 - 11)
Females, 12–19	1	484	1.03	3.3 (2.5 - 4.5)	1.0 (0.86 - 1.2)	2.8[E] (1.8 - 3.9)	6.1 (4.0 - 8.1)	F
Females, 12–19	2	250	0.80	1.9 (1.6 - 2.2)	0.73 (0.54 - 0.91)	1.9 (1.6 - 2.2)	2.9 (2.4 - 3.4)	5.9 (4.1 - 7.6)
Females, 20–39	1	364	0.27	4.4 (3.6 - 5.4)	1.5 (1.0 - 2.0)	3.6[E] (2.3 - 5.0)	7.3[E] (4.6 - 10)	26[E] (11 - 41)
Females, 20–39	2	183	0.55	1.5 (1.2 - 1.9)	0.52[E] (0.21 - 0.83)	1.3[E] (0.77 - 1.9)	2.3[E] (1.4 - 3.3)	x
Females, 40–59[c]	1							
Females, 40–59	2	159	0.63	2.1 (1.7 - 2.6)	0.91 (0.60 - 1.2)	1.9 (1.3 - 2.5)	2.9[E] (1.8 - 3.9)	x
Females, 60–79[c]	1							
Females, 60–79	2	141	1.42	1.8 (1.5 - 2.1)	0.71[E] (0.44 - 0.98)	1.6 (1.3 - 2.0)	2.9 (1.9 - 4.0)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.11 MONO-(2-ETHYL-5-OXOHEXYL) PHTHALATE (MEOHP)

Table 15.11.1

Mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3235	0	14 (13 - 16)	3.4 (2.7 - 4.0)	13 (12 - 15)	28 (26 - 31)	110 (74 - 140)
Total, 6–49	2	1608	0	7.8 (7.1 - 8.6)	2.5 (2.1 - 2.8)	7.9 (7.2 - 8.6)	15 (14 - 16)	34 (25 - 43)
Males, Total 6–49	1	1629	0	15 (13 - 17)	3.8 (2.9 - 4.7)	14 (11 - 16)	29 (25 - 33)	110^{E} (56 - 160)
Males, Total 6–49	2	809	0	8.2 (7.0 - 9.7)	2.5^{E} (1.5 - 3.5)	8.1 (7.2 - 8.9)	15 (13 - 18)	42^{E} (23 - 61)
Females, Total 6–49	1	1606	0	13 (12 - 15)	3.2 (2.4 - 4.0)	13 (11 - 15)	28 (25 - 31)	110^{E} (62 - 150)
Females, Total 6–49	2	799	0	7.5 (6.8 - 8.2)	2.5 (2.1 - 2.9)	7.1 (5.4 - 8.8)	15 (12 - 17)	28 (20 - 35)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.11.2

Mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2561	0	7.4 (6.9 - 8.0)	2.3 (2.1 - 2.5)	7.4 (6.7 - 8.1)	14 (12 - 15)	34 (30 - 39)
3–5[b]	1							
3–5	2	523	0	17 (15 - 19)	6.0 (4.7 - 7.2)	17 (15 - 20)	29 (23 - 35)	67^{E} (38 - 95)
6–11	1	1037	0	20 (18 - 22)	5.5 (4.7 - 6.4)	20 (17 - 22)	38 (32 - 43)	100 (84 - 120)
6–11	2	516	0	15 (13 - 18)	4.7 (3.4 - 6.1)	16 (12 - 20)	27 (22 - 31)	57 (50 - 65)
12–19	1	991	0	18 (15 - 21)	4.5 (3.6 - 5.5)	17 (15 - 20)	33 (29 - 37)	99^{E} (43 - 150)
12–19	2	512	0	10 (8.6 - 12)	3.2^{E} (1.7 - 4.7)	9.9 (8.6 - 11)	19 (16 - 22)	44 (30 - 59)
20–39	1	730	0	13 (11 - 15)	3.5 (2.6 - 4.4)	13 (10 - 15)	25 (21 - 29)	75^{E} (32 - 120)
20–39	2	359	0	6.6 (5.6 - 7.8)	2.4 (1.9 - 2.9)	6.7 (5.4 - 8.0)	12 (8.0 - 15)	24^{E} (14 - 35)
40–59[b]	1							
40–59	2	360	0	6.6 (5.5 - 7.9)	2.3 (1.7 - 2.8)	6.2 (5.1 - 7.2)	11 (8.9 - 13)	26^{E} (16 - 36)
60–79[b]	1							
60–79	2	291	0	6.0 (5.1 - 7.0)	2.0 (1.5 - 2.5)	6.0 (4.7 - 7.4)	10 (8.4 - 12)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.11.3

Mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1282	0	7.9 (6.8 - 9.2)	2.4 (2.0 - 2.8)	7.8 (7.0 - 8.7)	15 (12 - 17)	37[E] (22 - 52)
Males, 6–11	1	525	0	20 (17 - 24)	5.8 (4.2 - 7.5)	20 (17 - 23)	37 (33 - 41)	100 (70 - 130)
Males, 6–11	2	262	0	16 (13 - 20)	4.6[E] (2.3 - 6.8)	17 (11 - 22)	30 (22 - 37)	58 (47 - 68)
Males, 12–19	1	506	0	16 (14 - 19)	4.3 (3.2 - 5.5)	16 (14 - 18)	30 (27 - 34)	90[E] (42 - 140)
Males, 12–19	2	256	0	11 (8.8 - 13)	4.1[E] (2.3 - 6.0)	9.9 (8.8 - 11)	18 (16 - 21)	44[E] (20 - 68)
Males, 20–39	1	366	0	14 (12 - 17)	4.1 (2.7 - 5.4)	13 (9.7 - 16)	25 (20 - 30)	79[E] (49 - 110)
Males, 20–39	2	168	0	7.5 (5.7 - 9.8)	2.7 (1.7 - 3.6)	7.8 (6.6 - 9.0)	14 (11 - 18)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	0	6.6 (5.0 - 8.7)	2.1[E] (1.0 - 3.2)	7.0 (5.0 - 9.0)	11[E] (4.7 - 17)	x
Males, 60–79[c]	1							
Males, 60–79	2	142	0	6.3 (5.0 - 7.8)	2.1[E] (1.3 - 2.8)	6.4 (5.2 - 7.5)	9.9 (7.4 - 12)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1279	0	7.0 (6.5 - 7.6)	2.3 (2.0 - 2.6)	6.7 (5.7 - 7.8)	12 (9.7 - 15)	29 (23 - 36)
Females, 6–11	1	512	0	19 (16 - 23)	5.3 (4.1 - 6.6)	19 (16 - 22)	40 (30 - 49)	100 (81 - 120)
Females, 6–11	2	254	0	14 (12 - 17)	4.8 (3.4 - 6.3)	15 (11 - 19)	24 (19 - 29)	53 (34 - 71)
Females, 12–19	1	485	0	19 (15 - 25)	4.8[E] (2.9 - 6.6)	20 (16 - 24)	36 (29 - 42)	F
Females, 12–19	2	256	0	9.9 (7.6 - 13)	F	10 (6.9 - 13)	20 (15 - 25)	44 (31 - 57)
Females, 20–39	1	364	0	13 (11 - 15)	3.3 (2.5 - 4.0)	12 (9.6 - 15)	25 (19 - 32)	F
Females, 20–39	2	191	0	5.8 (4.9 - 7.0)	2.3 (1.5 - 3.1)	6.0 (4.9 - 7.1)	9.9 (7.6 - 12)	x
Females, 40–59[c]	1							
Females, 40–59	2	166	0	6.6 (5.5 - 7.9)	2.4 (1.8 - 3.0)	6.0 (5.3 - 6.8)	11 (8.7 - 14)	x
Females, 60–79[c]	1							
Females, 60–79	2	149	0	5.7 (4.6 - 7.2)	1.6[E] (0.63 - 2.7)	5.7[E] (3.6 - 7.8)	10 (7.7 - 12)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.11.4

Mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3227	0	16 (14 - 17)	5.3 (4.7 - 5.9)	14 (12 - 15)	25 (21 - 28)	96 (72 - 120)
Total, 6–49	2	1600	0	6.9 (6.3 - 7.5)	2.6 (2.2 - 3.0)	6.3 (5.3 - 7.3)	11 (9.8 - 12)	27 (20 - 33)
Males, Total 6–49	1	1623	0	14 (13 - 15)	4.8 (4.3 - 5.2)	12 (10 - 13)	22 (17 - 26)	84 (55 - 110)
Males, Total 6–49	2	806	0	6.4 (5.7 - 7.3)	2.4 (1.9 - 3.0)	5.8 (4.8 - 6.8)	11 (9.2 - 13)	31 (24 - 39)
Females, Total 6–49	1	1604	0	18 (16 - 20)	6.7 (5.2 - 8.1)	15 (13 - 16)	27 (21 - 32)	100 (72 - 130)
Females, Total 6–49	2	794	0	7.3 (6.6 - 8.2)	3.0 (2.0 - 3.9)	7.1 (5.8 - 8.4)	11 (9.6 - 13)	22 (19 - 26)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 15.11.5

Mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2551	0	7.3 (6.9 - 7.7)	2.9 (2.5 - 3.2)	7.0 (6.4 - 7.6)	11 (10 - 12)	31 (28 - 35)
3–5[b]	1							
3–5	2	522	0	30 (27 - 33)	13 (11 - 16)	28 (25 - 31)	43 (35 - 50)	90[E] (55 - 130)
6–11	1	1034	0	30 (27 - 34)	12 (9.7 - 14)	28 (24 - 31)	48 (43 - 52)	120 (95 - 140)
6–11	2	514	0	17 (16 - 19)	7.7 (6.6 - 8.9)	17 (15 - 19)	25 (20 - 30)	53 (41 - 65)
12–19	1	989	0	15 (13 - 18)	5.5 (4.5 - 6.4)	13 (11 - 15)	23 (20 - 26)	F
12–19	2	510	0	7.8 (6.9 - 8.9)	3.3 (2.9 - 3.7)	7.7 (6.6 - 8.8)	12 (10 - 13)	25[E] (15 - 36)
20–39	1	728	0	14 (12 - 16)	5.2 (4.3 - 6.1)	12 (10 - 13)	20 (16 - 23)	84 (56 - 110)
20–39	2	357	0	5.7 (4.8 - 6.7)	2.4 (1.9 - 2.9)	5.0 (4.0 - 6.0)	9.4 (6.7 - 12)	20 (14 - 26)
40–59[b]	1							
40–59	2	358	0	6.6 (5.9 - 7.4)	2.8 (2.3 - 3.2)	6.6 (5.8 - 7.5)	9.9 (8.7 - 11)	22 (14 - 30)
60–79[b]	1							
60–79	2	290	0	6.9 (6.3 - 7.6)	3.1 (2.5 - 3.8)	7.0 (6.3 - 7.7)	10 (8.6 - 12)	18[E] (12 - 25)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

Table 15.11.6

Mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1278	0	6.7 (6.0 - 7.5)	2.6 (2.2 - 3.0)	6.2 (5.3 - 7.0)	11 (9.2 - 12)	32 (27 - 37)
Males, 6–11	1	523	0	31 (28 - 34)	12 (10 - 14)	29 (26 - 32)	47 (42 - 53)	130 (88 - 160)
Males, 6–11	2	261	0	18 (16 - 21)	7.4 (5.8 - 8.9)	18 (16 - 21)	30 (22 - 37)	52 (42 - 63)
Males, 12–19	1	505	0	14 (12 - 16)	4.9 (3.6 - 6.1)	12 (10 - 14)	22 (18 - 26)	F
Males, 12–19	2	255	0	7.5 (6.5 - 8.7)	3.2 (2.8 - 3.7)	7.2 (5.9 - 8.4)	11 (9.1 - 14)	F
Males, 20–39	1	364	0	12 (10 - 14)	4.7 (3.8 - 5.6)	9.9 (8.3 - 12)	17 (14 - 20)	63[E] (33 - 92)
Males, 20–39	2	167	0	5.4 (4.4 - 6.7)	2.3 (1.6 - 3.0)	4.7 (3.3 - 6.1)	8.4[E] (5.1 - 12)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	0	5.6 (4.5 - 7.0)	2.3 (1.6 - 3.1)	5.0 (3.4 - 6.7)	8.9 (6.4 - 11)	x
Males, 60–79[c]	1							
Males, 60–79	2	142	0	5.9 (5.0 - 7.0)	2.7 (2.0 - 3.4)	6.1 (4.9 - 7.2)	8.4 (6.5 - 10)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1273	0	8.0 (7.3 - 8.8)	3.2 (2.5 - 3.9)	7.8 (6.9 - 8.8)	12 (11 - 13)	26 (20 - 33)
Females, 6–11	1	511	0	30 (26 - 35)	11 (8.8 - 14)	26 (22 - 31)	48 (40 - 56)	110 (80 - 140)
Females, 6–11	2	253	0	16 (14 - 19)	8.0 (6.5 - 9.4)	16 (14 - 18)	21 (18 - 25)	51[E] (27 - 75)
Females, 12–19	1	484	0	17 (14 - 21)	6.9 (5.5 - 8.4)	14 (11 - 17)	23 (18 - 28)	F
Females, 12–19	2	255	0	8.1 (7.0 - 9.5)	3.3 (<LOD - 4.2)	8.1 (6.4 - 9.9)	12 (11 - 14)	25 (18 - 31)
Females, 20–39	1	364	0	16 (14 - 20)	6.7[E] (3.9 - 9.4)	14 (12 - 16)	22[E] (13 - 31)	100[E] (<LOD - 140)
Females, 20–39	2	190	0	5.9 (4.8 - 7.3)	2.4[E] (1.1 - 3.7)	5.0 (3.6 - 6.4)	11 (7.6 - 14)	x
Females, 40–59[c]	1							
Females, 40–59	2	164	0	7.8 (6.6 - 9.3)	3.2[E] (1.8 - 4.5)	7.7 (6.0 - 9.5)	11 (8.8 - 13)	x
Females, 60–79[c]	1							
Females, 60–79	2	148	0	8.1 (7.3 - 9.0)	3.6 (2.9 - 4.3)	8.2 (7.3 - 9.0)	11 (9.9 - 13)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

15.12 MONO-(2-ETHYL-5-HYDROXYHEXYL) PHTHALATE (MEHHP)

Table 15.12.1

Mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3235	0	23 (21 - 26)	5.3 (4.3 - 6.3)	23 (20 - 26)	47 (44 - 50)	180 (120 - 240)
Total, 6–49	2	1608	0.06	13 (12 - 15)	4.0 (3.3 - 4.7)	13 (12 - 14)	24 (22 - 27)	59 (46 - 72)
Males, Total 6–49	1	1629	0	26 (23 - 29)	6.2 (4.6 - 7.9)	25 (21 - 28)	50 (45 - 54)	180[E] (99 - 270)
Males, Total 6–49	2	809	0.12	14 (12 - 17)	4.1[E] (2.3 - 5.9)	14 (12 - 16)	25 (21 - 29)	71 (50 - 93)
Females, Total 6–49	1	1606	0	21 (19 - 25)	4.9 (3.4 - 6.3)	21 (18 - 23)	45 (40 - 50)	170[E] (89 - 250)
Females, Total 6–49	2	799	0	12 (11 - 13)	4.0 (3.2 - 4.7)	12 (10 - 13)	23 (20 - 27)	47 (41 - 52)

a For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 15.12.2

Mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2561	0.08	13 (12 - 14)	3.9 (3.4 - 4.4)	12 (12 - 13)	24 (22 - 25)	59 (48 - 70)
3–5[b]	1							
3–5	2	523	0	27 (23 - 30)	8.6 (6.4 - 11)	25 (21 - 30)	48 (36 - 61)	99[E] (59 - 140)
6–11	1	1037	0	31 (28 - 35)	8.8 (7.6 - 10)	31 (27 - 35)	60 (50 - 70)	180 (130 - 230)
6–11	2	516	0	24 (20 - 28)	7.0 (5.4 - 8.7)	24 (19 - 29)	43 (34 - 52)	97 (73 - 120)
12–19	1	991	0	29 (24 - 34)	7.5 (5.8 - 9.3)	29 (25 - 32)	56 (46 - 65)	160[E] (64 - 260)
12–19	2	512	0	16 (14 - 20)	4.6[E] (2.4 - 6.8)	16 (13 - 20)	32 (26 - 39)	68 (49 - 87)
20–39	1	730	0	22 (19 - 26)	5.7 (4.5 - 6.9)	21 (16 - 26)	45 (38 - 51)	150[E] (83 - 220)
20–39	2	359	0.28	11 (9.1 - 13)	3.8 (3.0 - 4.6)	12 (10 - 13)	21 (16 - 25)	40[E] (20 - 60)
40–59[b]	1							
40–59	2	360	0.28	12 (9.7 - 14)	4.1[E] (2.6 - 5.5)	11 (8.7 - 13)	21 (15 - 26)	44[E] (21 - 67)
60–79[b]	1							
60–79	2	291	0	10 (8.8 - 12)	3.4 (2.5 - 4.3)	10 (7.4 - 13)	19 (15 - 24)	44[E] (23 - 66)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

Table 15.12.3

Mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP) — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1282	0.08	14 (12 - 16)	4.2 (3.1 - 5.2)	13 (12 - 15)	25 (20 - 29)	69 (53 - 84)
Males, 6–11	1	525	0	32 (28 - 37)	9.2 (6.9 - 12)	33 (28 - 38)	60 (50 - 71)	170 (120 - 230)
Males, 6–11	2	262	0	26 (21 - 32)	6.9[E] (4.2 - 9.5)	25 (18 - 33)	47[E] (30 - 65)	98 (72 - 120)
Males, 12–19	1	506	0	27 (24 - 32)	7.6 (4.9 - 10)	27 (24 - 31)	50 (41 - 59)	150[E] (68 - 230)
Males, 12–19	2	256	0	17 (14 - 21)	6.0[E] (3.6 - 8.5)	16 (13 - 20)	34 (27 - 40)	71[E] (38 - 100)
Males, 20–39	1	366	0	25 (21 - 29)	7.4[E] (4.3 - 10)	24 (19 - 29)	46 (36 - 55)	160 (110 - 210)
Males, 20–39	2	168	0.60	13 (9.6 - 17)	4.4[E] (2.5 - 6.4)	13 (9.6 - 16)	24 (20 - 28)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	0	12 (9.2 - 16)	3.4[E] (1.8 - 5.0)	12 (9.2 - 16)	20[E] (10 - 30)	x
Males, 60–79[c]	1							
Males, 60–79	2	142	0	11 (8.6 - 14)	3.8 (2.7 - 4.9)	11 (7.5 - 14)	17[E] (11 - 23)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1279	0.08	12 (11 - 12)	3.8 (3.2 - 4.4)	11 (9.4 - 13)	23 (20 - 26)	47 (39 - 56)
Females, 6–11	1	512	0	30 (26 - 36)	8.1 (5.9 - 10)	30 (24 - 35)	61 (48 - 73)	180 (120 - 240)
Females, 6–11	2	254	0	22 (18 - 27)	7.3 (5.5 - 9.1)	23 (18 - 28)	35 (23 - 47)	84[E] (45 - 120)
Females, 12–19	1	485	0	30 (23 - 41)	7.5[E] (4.7 - 10)	32 (27 - 37)	61 (47 - 74)	F
Females, 12–19	2	256	0	16 (12 - 20)	F	16 (12 - 21)	31 (22 - 39)	67 (44 - 90)
Females, 20–39	1	364	0	20 (17 - 24)	5.4 (4.1 - 6.8)	18 (13 - 23)	40 (28 - 53)	F
Females, 20–39	2	191	0	9.5 (7.8 - 11)	3.7 (2.5 - 5.0)	9.6 (6.6 - 13)	17 (13 - 21)	x
Females, 40–59[c]	1							
Females, 40–59	2	166	0.60	11 (9.4 - 13)	4.8 (4.1 - 5.4)	10 (8.4 - 12)	22 (14 - 29)	x
Females, 60–79[c]	1							
Females, 60–79	2	149	0	9.9 (8.0 - 12)	2.8[E] (1.3 - 4.4)	9.9 (6.8 - 13)	21 (16 - 26)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 15.12.4

Mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 6–49 years[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 6–49	1	3227	0	26 (24 - 29)	8.6 (7.5 - 9.7)	22 (21 - 24)	42 (36 - 48)	160 (110 - 200)
Total, 6–49	2	1600	0.08	12 (10 - 13)	4.7 (3.9 - 5.6)	11 (9.6 - 12)	19 (16 - 22)	48 (37 - 59)
Males, Total 6–49	1	1623	0	24 (22 - 26)	7.8 (7.0 - 8.7)	20 (18 - 22)	39 (31 - 47)	140[E] (81 - 200)
Males, Total 6–49	2	806	0.08	11 (9.7 - 13)	4.1 (2.7 - 5.4)	10 (8.9 - 12)	19 (16 - 23)	54 (41 - 68)
Females, Total 6–49	1	1604	0	28 (25 - 32)	9.9 (8.4 - 12)	24 (22 - 26)	44 (35 - 53)	170 (120 - 220)
Females, Total 6–49	2	794	0.08	12 (11 - 13)	5.2 (4.6 - 5.9)	12 (10 - 14)	19 (16 - 22)	35 (28 - 42)

[a] For the purpose of total population comparisons, only values from participants aged 6–49 years were included as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[E] Use data with caution.

Table 15.12.5

Mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79[b]	1							
Total, 3–79	2	2551	0.08	12 (12 - 13)	5.1 (4.5 - 5.6)	12 (11 - 13)	20 (18 - 21)	52 (44 - 60)
3–5[b]	1							
3–5	2	522	0	46 (41 - 51)	21 (18 - 24)	42 (37 - 47)	67 (54 - 80)	130[E] (66 - 190)
6–11	1	1034	0	48 (44 - 53)	19 (16 - 22)	44 (39 - 48)	75 (65 - 85)	190 (150 - 240)
6–11	2	514	0	27 (24 - 30)	12 (10 - 14)	25 (23 - 28)	40 (33 - 47)	90 (66 - 110)
12–19	1	989	0	25 (21 - 29)	9.0 (7.9 - 10)	22 (18 - 25)	39 (32 - 46)	F
12–19	2	510	0	13 (11 - 14)	5.1 (4.2 - 6.0)	12 (11 - 14)	19 (16 - 23)	37[E] (15 - 60)
20–39	1	728	0	23 (21 - 26)	8.5 (6.7 - 10)	20 (18 - 22)	35 (29 - 40)	140 (93 - 190)
20–39	2	357	0.28	9.4 (7.9 - 11)	4.0 (2.7 - 5.3)	8.5 (6.0 - 11)	14 (9.7 - 19)	29[E] (15 - 44)
40–59[b]	1							
40–59	2	358	0.28	12 (11 - 13)	5.1 (4.3 - 6.0)	12 (11 - 13)	17 (14 - 19)	36[E] (18 - 54)
60–79[b]	1							
60–79	2	290	0	12 (11 - 13)	5.3 (4.4 - 6.2)	13 (11 - 14)	18 (16 - 19)	35 (26 - 43)

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

[b] Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

[E] Use data with caution.

[F] Data is too unreliable to be published.

Table 15.12.6

Mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP) (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 1 (2007–2009) and cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79[c]	1							
Males, Total 3–79	2	1278	0.08	12 (10 - 13)	4.3 (3.3 - 5.3)	11 (9.5 - 12)	19 (16 - 22)	59 (45 - 72)
Males, 6–11	1	523	0	49 (46 - 53)	20 (17 - 22)	45 (41 - 50)	74 (63 - 85)	200[E] (120 - 280)
Males, 6–11	2	261	0	29 (25 - 34)	12 (9.3 - 15)	29 (23 - 35)	48 (34 - 61)	91 (69 - 110)
Males, 12–19	1	505	0	23 (20 - 27)	8.4 (6.2 - 11)	21 (18 - 23)	39 (33 - 45)	F
Males, 12–19	2	255	0	12 (10 - 14)	5.0 (3.9 - 6.0)	12 (10 - 15)	19 (14 - 23)	F
Males, 20–39	1	364	0	21 (18 - 24)	7.3 (5.7 - 8.9)	18 (16 - 20)	30 (23 - 36)	120[E] (67 - 170)
Males, 20–39	2	167	0.60	9.3 (7.5 - 12)	3.3[E] (1.7 - 4.9)	9.8 (6.9 - 13)	13[E] (7.2 - 19)	x
Males, 40–59[c]	1							
Males, 40–59	2	194	0	10 (8.3 - 13)	4.2 (2.8 - 5.6)	9.5 (6.6 - 12)	16 (11 - 21)	x
Males, 60–79[c]	1							
Males, 60–79	2	142	0	10 (8.4 - 12)	4.8 (3.4 - 6.1)	9.4 (7.1 - 12)	16 (12 - 19)	x
Females, Total 3–79[c]	1							
Females, Total 3–79	2	1273	0.08	13 (12 - 14)	5.4 (4.9 - 6.0)	13 (12 - 14)	21 (19 - 22)	43 (35 - 52)
Females, 6–11	1	511	0	47 (41 - 54)	17 (14 - 21)	42 (36 - 49)	76 (63 - 89)	190[E] (110 - 260)
Females, 6–11	2	253	0	25 (22 - 29)	12 (9.5 - 14)	23 (20 - 27)	34 (29 - 40)	81[E] (46 - 120)
Females, 12–19	1	484	0	27 (21 - 34)	10 (8.5 - 12)	23 (18 - 27)	39 (28 - 50)	F
Females, 12–19	2	255	0	13 (11 - 15)	5.1 (3.9 - 6.3)	12 (10 - 15)	20 (16 - 24)	37 (28 - 46)
Females, 20–39	1	364	0	26 (22 - 32)	9.8 (6.7 - 13)	22 (19 - 25)	37[E] (20 - 54)	180[E] (<LOD - 260)
Females, 20–39	2	190	0	9.6 (7.7 - 12)	4.5 (2.9 - 6.1)	8.5[E] (5.3 - 12)	14[E] (8.7 - 20)	x
Females, 40–59[c]	1							
Females, 40–59	2	164	0.61	13 (11 - 15)	5.7 (4.1 - 7.3)	13 (11 - 15)	19 (15 - 22)	x
Females, 60–79[c]	1							
Females, 60–79	2	148	0	14 (13 - 15)	5.7 (4.3 - 7.0)	15 (13 - 17)	19 (16 - 22)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

c Data not available as participants under the age of 6 years and over the age of 49 were not included in cycle 1 (2007–2009).

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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POLYCYCLIC AROMATIC HYDROCARBON METABOLITE SUMMARIES AND RESULTS

16

16.1 OVERVIEW

Polycyclic aromatic hydrocarbons (PAHs) are a group of more than 100 organic compounds characterized by the presence of two or more fused aromatic rings. The World Health Organization and the United States Environmental Protection Agency have prioritized 16 PAHs because of their toxicity. Table 16.1 lists seven of these priority PAHs and their metabolites measured in cycle 2 of the Canadian Health Measures Survey (CHMS).

Table 16.1.1

Hydroxylated polyaromatic hydrocarbon (PAH) metabolites measured in the Canadian Health Measures Survey cycle 2 (2009–2011) and their parent PAH compounds.

PAH	CASRN	Hydroxylated PAH metabolites	CASRN
Benzo[*a*]pyrene	50-32-8	3-Hydroxybenzo[*a*]pyrene	13345-21-6
Chrysene	218-01-9	2-Hydroxychrysene 3-Hydroxychrysene 4-Hydroxychrysene 6-Hydroxychrysene	65945-06-4 63019-39-6 63019-40-9 37515-51-8
Fluorene	86-73-7	2-Hydroxyfluorene 3-Hydroxyfluorene 9-Hydroxyfluorene	2443-58-5 6344-67-8 484-17-3
Fluoranthene	206-44-0	3-Hydroxyfluoranthene	206-44-0
Naphthalene	91-20-3	1-Hydroxynaphthalene 2-Hydroxynaphthalene	90-15-3 135-19-3
Phenanthrene	85-01-8	1-Hydroxyphenanthrene 2-Hydroxyphenanthrene 3-Hydroxyphenanthrene 4-Hydroxyphenanthrene 9-Hydroxyphenanthrene	2443-56-9 605-55-0 605-87-8 7651-86-7 484-17-3
Pyrene	129-00-0	1-Hydroxypyrene	5315-79-7

PAHs are released to the environment from both natural and anthropogenic sources; the contribution from anthropogenic sources is substantially higher than from natural sources (ATSDR, 1995). In Canada, forest fires are the largest natural source of PAHs in the environment (Environment Canada, 2010). Other natural sources include crude oils, coal, and volcanic eruptions. Anthropogenic PAH emissions are predominantly due to the incomplete combustion of organic substances from waste incineration, tobacco smoke, cooking, automobile exhaust, mining and refining operations, oil spills, and the use of creosote-treated products (ATSDR, 1995; ATSDR, 2005; Environment Canada & Health Canada, 1994).

For the general population, the major routes of exposure to PAHs are from diet, smoking, and ambient and indoor air (IARC, 2010; WHO, 2011). Levels in food depend on the source of the food and the method of cooking (ATSDR, 1995). PAHs can be formed when food is charbroiled, grilled, roasted, fried, or baked. Drinking water is considered to be a negligible source of exposure in Canada (Environment Canada & Health Canada, 1994). Vehicle exhaust, tobacco smoke, emissions from wood and charcoal-fired stoves, house dust, and ambient air all contribute to inhalation exposure. Human exposure to PAHs may also occur through skin contact with soot and tars (ATSDR, 1995).

PAHs can be absorbed following inhalation, oral, and dermal exposure. They undergo multi-step metabolism leading to several types of metabolites, including hydroxylated PAHs (Strickland et al., 1996). Elimination occurs through urine and feces, with urinary hydroxylated PAH metabolites observed within a few days of exposure (Viau et al., 1995). These metabolites are excreted both in the free form and as glucuronic acid and sulphate conjugates (Castano-Vinyals et al., 2004).

Several approaches exist to assess human exposure to PAHs. The analysis of urinary hydroxylated PAH metabolites is the most common approach and has been used in several biomonitoring studies (Becker et al., 2003; CDC, 2009). Several urinary hydroxylated PAH metabolites were measured in cycle 2 of the CHMS and are listed along with their parent PAHs in Table 16.1.1.

Evaluating health effects of exposure to individual PAHs in humans is difficult because exposure is generally to multiple PAHs at the same time. Studies in laboratory animals have shown that several PAHs have carcinogenic, mutagenic, and teratogenic potential (IARC, 2010; IARC, 2012). The carcinogenic potency of PAHs appears to differ considerably among exposure routes (ATSDR, 1995). In some, formation of epoxides through metabolic activation of PAHs is considered a key step in eliciting carcinogenic effects (D'Mello et al., 2003). Benzo[*a*]pyrene, PAH-containing mixtures, such as soot and coal tar, and occupational exposures in PAH-related industries (coal-tar distillation, coal gasification, coke production, aluminium production) have recently been confirmed as carcinogenic to humans by the International Agency for Research on Cancer (IARC) (IARC, 2012). Based on current data, IARC has classified some PAHs, such as chrysene and naphthalene, as possibly carcinogenic to humans (IARC, 2010). Other PAHs, such as fluoranthene, fluorine, phenanthrene, and pyrene, are not classifiable as to their carcinogenicity to humans (IARC, 2010). PAHs also exhibit immunological, hepatic, and reproductive effects in laboratory animals, but generally at doses much higher than those that elicit a carcinogenic response (ATSDR, 1995).

In Canada, PAHs are listed as toxic substances on Schedule 1 of the *Canadian Environmental Protection Act, 1999*, based on an evaluation of the environmental and health effects of several PAHs, including benzo[*a*]pyrene (Canada, 1999; Canada, 2000; Environment Canada & Health Canada, 1994). Several environmental performance agreements, codes of practice, and recommendations have been established to reduce releases of PAHs to the environment from the aluminum and steel manufacturing and wood preservation sectors (Environment Canada, 2010). In order to minimize exposure to PAHs from a specific food product called olive-pomace oil, Health Canada has established a maximum PAH contaminant concentration for the oil (Health Canada, 2012).

In the following sections, some common PAHs (see Table 16.1.1) are discussed, and data on their urinary hydroxylated PAH metabolites and baseline levels found in the Canadian population are presented.

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16.2 BENZO[*a*]PYRENE METABOLITE

Benzo[*a*]pyrene is a polycyclic aromatic hydrocarbon (PAH) composed of five fused benzene rings. It is not manufactured in Canada and no industrial uses are known (Health Canada, 1988).

In laboratory rats, about 40% to 60% of benzo[*a*]pyrene is absorbed following exposure through gavage or diet (Faust, 1994). Based on laboratory studies, approximately 3% of benzo[*a*]pyrene is expected to be absorbed through skin after 24 hours (Kao et al., 1985). The presence of urinary metabolites in workers exposed occupationally to PAHs in air provides evidence for absorption of benzo[*a*]pyrene following inhalation (ATSDR, 1995). Its absorption following inhalation is highly dependent on the type of particles onto which it is adsorbed. After absorption, benzo[*a*]pyrene distributes to several organs including lungs, liver, and intestines (Faust, 1994). Like other PAHs, benzo[*a*]pyrene is metabolized to various arene epoxides that after rearrangement produce several hydroxylated PAHs and dihydrodiols (Bouchard & Viau, 1996). The metabolite 3-hydroxybenzo[*a*]pyrene has been used as a biomarker in urine for exposure to benzo[*a*]pyrene in humans (Chien & Yeh, 2012).

Adverse health effects have been observed in laboratory animals following benzo[*a*]pyrene exposure via inhalation, oral, and dermal routes. Non-carcinogenic effects have been observed at dose levels on at least an order of magnitude higher than that of carcinogenic effects (ATSDR, 1995; Health Canada, 1988; Jules et al., 2012). The diolepoxides formed during metabolism of benzo[*a*]pyrene are considered to be the primary carcinogenic agents (IARC, 2012). Although there is no direct evidence for the carcinogenic effects in humans, occupational exposures to benzo[*a*]pyrene-containing mixtures have been associated with a series of cancers (IARC, 2012). Based on the strong evidence for the carcinogenicity of benzo[*a*]pyrene in many animal species, and supported by evidence from laboratory and human studies, the International Agency for Research on Cancer has classified benzo[*a*]pyrene as Group 1, a known human carcinogen (IARC, 2012).

Health Canada has developed a Canadian drinking water quality guideline that sets out the maximum acceptable concentration of benzo[*a*]pyrene (Health Canada, 1988); this guideline is currently under review.

The benzo[*a*]pyrene metabolite, 3-hydroxybenzo[*a*]pyrene, was measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and is presented as both µg/L and µg/g creatinine (Tables 16.2.1.1, 16.2.1.2, 16.2.1.3, and 16.2.1.4). Finding a measurable amount of 3-hydroxybenzo[*a*]pyrene in urine is an indicator of exposure to benzo[*a*]pyrene and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary 3-hydroxybenzo[*a*]pyrene in the Canadian population.

16.2.1 3-Hydroxybenzo[*a*]pyrene

Table 16.2.1.1

3-Hydroxybenzo[*a*]pyrene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2294	99.91	—	<LOD	<LOD	<LOD	<LOD
3–5	2	420	99.76	—	<LOD	<LOD	<LOD	<LOD
6–11	2	466	99.79	—	<LOD	<LOD	<LOD	<LOD
12–19	2	473	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	328	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	340	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	267	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.2.1.2

3-Hydroxybenzo[*a*]pyrene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1163	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	240	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	236	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	160	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	188	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	135	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1131	99.82	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	226	99.56	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	237	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	168	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	152	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	132	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.2.1.3

3-Hydroxybenzo[*a*]pyrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2284	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	419	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	464	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	471	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	326	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	338	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	266	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.2.1.4

3-Hydroxybenzo[*a*]pyrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1159	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	239	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	235	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	159	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	188	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	135	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1125	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	225	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	236	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	167	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	150	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	131	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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16.3 CHRYSENE METABOLITES

Chrysene is a polycyclic aromatic hydrocarbon (PAH) composed of four fused benzene rings. There are no known uses of chrysene other than its use as a research chemical (ATSDR, 1995).

Chrysene is highly lipophilic. In animal pharmacokinetic studies, approximately 75% of chrysene was absorbed when administered through oral, inhalation, and dermal routes of exposure; after absorption, it preferentially distributed to adipose tissues (Borges, 1994). Chrysene is metabolized into several mono- and dihydroxychrysene metabolites (CDC, 2009). Chrysene metabolites are excreted predominantly in the feces. However, PAH biomonitoring studies in humans have attempted to measure urinary levels of 1-, 2-, 3-, 4, and 6-hydroxychrysene, and have been able to detect urinary 3- and 6-hydroxychrysene in a small proportion of samples (Nethery et al., 2012).

Data on the systemic toxicity of chrysene in animals and humans are limited (Borges, 1994). In mice, chrysene exposure resulted in an increased incidence of skin papillomas and hepatic and lung tumours (Chang et al., 1983; Wislocki et al., 1986). Based on a limited amount of available carcinogenicity data, the International Agency for Research on Cancer has classified chrysene as Group 2B, possibly carcinogenic to humans (IARC, 2010).

The urinary chrysene metabolites 3- and 6-hydroxychrysene were measured for 73 non-smoking, non-occupationally exposed individuals (aged 16 to 64 years) living approximately 1 km from an aluminum plant in Baie-Comeau, Quebec. These chrysene metabolites were measured as part of a broad set of PAH metabolites. Although the levels of some other urinary PAH metabolites were higher compared with a control group of 71 individuals living at least 11 km from the plant, the urinary concentrations of these chrysene metabolites were below the limit of detection (0.032 µg/L for 3-hydroxychrysene and 0.019 µg/L for 6-hydroxychrysene) for most samples (Bouchard et al., 2009).

The chrysene metabolites, 2-, 3-, 4-, and 6-hydroxychrysene, were measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and are presented as both µg/L and µg/g creatinine (Tables 16.3.1.1 to 16.4.4). Given that chrysene metabolites are predominantly excreted in the feces, their urinary absence alone does not indicate that exposure to chrysene did not occur. Finding a measurable amount of chrysene metabolites in urine is an indicator of exposure to chrysene and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary chrysene metabolites in the Canadian population.

16.3.1 2-Hydroxychrysene

Table 16.3.1.1

2-Hydroxychrysene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2497	99.84	—	<LOD	<LOD	<LOD	<LOD
3–5	2	499	99.60	—	<LOD	<LOD	<LOD	<LOD
6–11	2	508	99.80	—	<LOD	<LOD	<LOD	<LOD
12–19	2	498	99.80	—	<LOD	<LOD	<LOD	<LOD
20–39	2	352	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	357	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	283	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.3.1.2

2-Hydroxychrysene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1254	99.92	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	259	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	253	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	165	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	192	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	139	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1243	99.76	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	249	99.60	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	245	99.59	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	187	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	165	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	144	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.3.1.3

2-Hydroxychrysene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2487	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	498	99.80	—	<LOD	<LOD	<LOD	<LOD
6–11	2	506	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	496	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	350	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	355	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	282	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.3.1.4

2-Hydroxychrysene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1250	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	258	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	252	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	164	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	192	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	139	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1237	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	248	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	244	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	186	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	163	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	143	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

16.3.2 3-Hydroxychrysene

Table 16.3.2.1

3-Hydroxychrysene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2495	99.76	—	<LOD	<LOD	<LOD	<LOD
3–5	2	499	99.60	—	<LOD	<LOD	<LOD	<LOD
6–11	2	506	99.41	—	<LOD	<LOD	<LOD	<LOD
12–19	2	498	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	351	99.72	—	<LOD	<LOD	<LOD	<LOD
40–59	2	358	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	283	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.3.2.2

3-Hydroxychrysene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1255	99.92	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	258	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	164	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	140	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1240	99.60	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	248	98.79	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	244	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	187	99.47	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	165	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	143	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.3.2.3

3-Hydroxychrysene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2485	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	498	99.80	—	<LOD	<LOD	<LOD	<LOD
6–11	2	504	99.80	—	<LOD	<LOD	<LOD	<LOD
12–19	2	496	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	349	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	356	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	282	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.3.2.4

3-Hydroxychrysene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1251	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	257	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	253	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	163	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	140	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1234	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	247	99.19	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	243	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	186	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	163	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

16.3.3 4-Hydroxychrysene

■ Table 16.3.3.1

4-Hydroxychrysene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2498	99.76	—	<LOD	<LOD	<LOD	<LOD
3–5	2	498	99.80	—	<LOD	<LOD	<LOD	<LOD
6–11	2	508	99.61	—	<LOD	<LOD	<LOD	<LOD
12–19	2	499	99.80	—	<LOD	<LOD	<LOD	<LOD
20–39	2	352	99.72	—	<LOD	<LOD	<LOD	<LOD
40–59	2	358	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	283	99.65	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

■ Table 16.3.3.2

4-Hydroxychrysene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1257	99.76	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	260	99.62	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	254	99.61	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	165	99.39	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	140	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1241	99.76	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	248	99.60	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	245	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	187	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	165	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	143	99.30	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.3.3.3

4-Hydroxychrysene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2488	100	—	<LOD	<LOD	<LOD	<LOD
3–5	2	497	100	—	<LOD	<LOD	<LOD	<LOD
6–11	2	506	100	—	<LOD	<LOD	<LOD	<LOD
12–19	2	497	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	350	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	356	100	—	<LOD	<LOD	<LOD	<LOD
60–79	2	282	100	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.3.3.4

4-Hydroxychrysene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1253	100	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	259	100	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	253	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	164	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	193	100	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	140	100	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1235	100	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	247	100	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	244	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	186	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	163	100	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	142	100	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

16.3.4 6-Hydroxychrysene

Table 16.3.4.1

6-Hydroxychrysene — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2459	96.87	—	<LOD	<LOD	<LOD	<LOD
3–5	2	494	97.37	—	<LOD	<LOD	<LOD	<LOD
6–11	2	499	95.79	—	<LOD	<LOD	<LOD	<LOD
12–19	2	489	97.55	—	<LOD	<LOD	<LOD	<LOD
20–39	2	344	96.80	—	<LOD	<LOD	<LOD	<LOD
40–59	2	354	96.33	—	<LOD	<LOD	<LOD	<LOD
60–79	2	279	97.49	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.3.4.2

6-Hydroxychrysene — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1239	96.37	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	255	95.69	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	250	97.20	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	162	96.91	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	191	95.81	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	136	97.06	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1220	97.38	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	244	95.90	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	239	97.91	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	182	96.70	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	163	96.93	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	143	97.90	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.3.4.3

6-Hydroxychrysene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2449	97.26	—	<LOD	<LOD	<LOD	<LOD
3–5	2	493	97.57	—	<LOD	<LOD	<LOD	<LOD
6–11	2	497	96.18	—	<LOD	<LOD	<LOD	<LOD
12–19	2	487	97.95	—	<LOD	<LOD	<LOD	<LOD
20–39	2	342	97.37	—	<LOD	<LOD	<LOD	<LOD
40–59	2	352	96.88	—	<LOD	<LOD	<LOD	<LOD
60–79	2	278	97.84	—	<LOD	<LOD	<LOD	<LOD

[a] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.3.4.4

6-Hydroxychrysene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1235	96.68	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	254	96.06	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	249	97.59	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	161	97.52	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	191	95.81	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	136	97.06	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1214	97.86	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	243	96.30	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	238	98.32	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	181	97.24	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	161	98.14	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	142	98.59	—	<LOD	<LOD	<LOD	x

[a] Breakdown by sex for the 3–5 year old age group is not recommended.

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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16.4 FLUORANTHENE METABOLITE

Fluoranthene, also known as benzo[*j,k*]fluorene, is a polycyclic aromatic hydrocarbon (PAH) with five fused aromatic rings. It is found naturally in the environment in some bacteria, algae, and plants and as a result of anthropogenic releases from incomplete combustion of organic substances (EPA, 1980). Fluoranthene is used in the synthesis of dyes and in biomedical research (Wu et al., 2010).

Limited pharmacokinetic data for fluoranthene are available. Similar to other structurally related PAHs, fluoranthene may be absorbed following oral, inhalation, or dermal exposure (Faust, 1993; Storer et al., 1984). Because of its high lipophilicity, fluoranthene distributes to adipose tissue (EPA, 1980). Metabolism of fluoranthene produces hydroxylated metabolites, and urinary 3-hydroxyfluoranthene is considered an indicator of recent exposures.

Kidney and liver effects were observed in rats orally administered fluoranthene (Faust, 1993). Fluoranthene exposure in mice has resulted in lung tumours (Busby Jr. et al., 1989; IARC, 2010). Dermal exposure in mice to a combination of benzo[*a*]pyrene and fluoranthene significantly increased the incidence of skin tumours (IARC, 2010). Based on the limited data on fluoranthene carcinogenicity, the International Agency for Research on Cancer has classified fluoranthene as Group 3, not classifiable as to its carcinogenicity to humans (IARC, 2010).

The urinary fluoranthene metabolite, 3-hydroxyfluoranthene, was measured for 73 non-smoking, non-occupationally exposed individuals (aged 16 to 64 years) living approximately 1 km from an aluminum plant in Baie-Comeau, Quebec. The fluoranthene metabolite was measured as part of a broad set of PAH metabolites. Although the levels of some other urinary PAH metabolites were higher compared with a control group of 71 individuals living at least 11 km from the plant, the concentration of 3-hydroxyfluoranthene was below the limit of detection (0.030 µg/L) for most samples (Bouchard et al., 2009).

The fluoranthene metabolite, 3-hydroxyfluoranthene, was measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and is presented as both µg/L and µg/g creatinine (Tables 16.4.1.1, 16.4.1.2, 16.4.1.3, and 16.4.1.4). Finding a measurable amount of 3-hydroxyfluoranthene in urine is an indicator of exposure to fluoranthene and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary 3-hydroxyfluoranthene in the Canadian population.

16.4.1 3-Hydroxyfluoranthene

Table 16.4.1.1

3-Hydroxyfluoranthene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2265	98.23	—	<LOD	<LOD	<LOD	<LOD
3–5	2	428	97.20	—	<LOD	<LOD	<LOD	<LOD
6–11	2	463	97.41	—	<LOD	<LOD	<LOD	<LOD
12–19	2	460	99.57	—	<LOD	<LOD	<LOD	<LOD
20–39	2	319	99.69	—	<LOD	<LOD	<LOD	<LOD
40–59	2	329	97.87	—	<LOD	<LOD	<LOD	<LOD
60–79	2	266	97.74	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.4.1.2

3-Hydroxyfluoranthene — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1145	98.25	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	237	98.31	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	240	99.58	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	154	99.35	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	177	97.74	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	130	96.92	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1120	98.21	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	226	96.46	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	220	99.55	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	165	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	152	98.03	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	136	98.53	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.4.1.3

3-Hydroxyfluoranthene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (μg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2257	98.58	—	<LOD	<LOD	<LOD	<LOD
3–5	2	428	97.20	—	<LOD	<LOD	<LOD	<LOD
6–11	2	462	97.62	—	<LOD	<LOD	<LOD	<LOD
12–19	2	458	100	—	<LOD	<LOD	<LOD	<LOD
20–39	2	317	100	—	<LOD	<LOD	<LOD	<LOD
40–59	2	327	98.47	—	<LOD	<LOD	<LOD	<LOD
60–79	2	265	98.11	—	<LOD	<LOD	<LOD	<LOD

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 16.4.1.4

3-Hydroxyfluoranthene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1142	98.51	—	<LOD	<LOD	<LOD	<LOD
Males, 6–11	2	236	98.73	—	<LOD	<LOD	<LOD	<LOD
Males, 12–19	2	239	100	—	<LOD	<LOD	<LOD	<LOD
Males, 20–39	2	153	100	—	<LOD	<LOD	<LOD	x
Males, 40–59	2	177	97.74	—	<LOD	<LOD	<LOD	x
Males, 60–79	2	130	96.92	—	<LOD	<LOD	<LOD	x
Females, Total 3–79	2	1115	98.65	—	<LOD	<LOD	<LOD	<LOD
Females, 6–11	2	226	96.46	—	<LOD	<LOD	<LOD	<LOD
Females, 12–19	2	219	100	—	<LOD	<LOD	<LOD	<LOD
Females, 20–39	2	164	100	—	<LOD	<LOD	<LOD	x
Females, 40–59	2	150	99.33	—	<LOD	<LOD	<LOD	x
Females, 60–79	2	135	99.26	—	<LOD	<LOD	<LOD	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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16.5 FLUORENE METABOLITES

Fluorene is a polycyclic aromatic hydrocarbon (PAH) with three fused aromatic rings. Fluorene and its derivatives are used in the manufacture of dyes, pharmaceuticals, polymer materials, photonics, and basic research (Belfield et al., 1999; Bernius et al., 2000; Mondal et al., 2009).

Animal studies indicate that fluorene is absorbed following oral, inhalation, and dermal exposure (ATSDR, 1995). Metabolism of fluorene produces several hydroxylated metabolites that are further conjugated with glucuronic or sulphonic acids and rapidly eliminated in the urine (Faust, 1994). Several urinary monohydroxy fluorene metabolites, including 2-, 3-, and 9-hydroxyfluorene, have been identified in humans and are considered indicators of recent PAH exposure (Becker et al., 2003; CDC, 2009; Nethery et al., 2012). Urinary 3-hydroxyfluorene may be a good predictive biomarker for specifically assessing inhalation exposure to fluorene (Nethery et al., 2012).

Hematological and liver effects were observed in laboratory animals exposed orally to fluorene (ATSDR, 1995). Data on the carcinogenicity of fluorene in humans have not been identified and the International Agency for Research on Cancer has classified fluorene as Group 3, not classifiable as to its carcinogenicity in humans (IARC, 2010).

The fluorene metabolites, 2-, 3-, and 9-hydroxyfluorene, were measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and are presented as both µg/L and µg/g creatinine (Tables 16.5.1.1 to 16.5.3.4). Finding a measurable amount of fluorene metabolites in urine is an indicator of exposure to fluorene and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary fluorene metabolites in the Canadian population.

16.5.1 2-Hydroxyfluorene

Table 16.5.1.1

2-Hydroxyfluorene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2524	0	0.27 (0.24 - 0.30)	0.069 (0.058 - 0.080)	0.24 (0.21 - 0.27)	0.47 (0.38 - 0.57)	2.3 (1.7 - 2.8)
3–5	2	506	0	0.17 (0.16 - 0.19)	0.069 (0.061 - 0.077)	0.18 (0.16 - 0.20)	0.27 (0.21 - 0.32)	0.47 (0.32 - 0.62)
6–11	2	511	0	0.22 (0.18 - 0.25)	0.088 (0.077 - 0.10)	0.24 (0.19 - 0.29)	0.33 (0.29 - 0.38)	0.57 (0.38 - 0.76)
12–19	2	506	0	0.26 (0.24 - 0.29)	0.098 (0.073 - 0.12)	0.26 (0.22 - 0.30)	0.42 (0.35 - 0.50)	1.1 (0.87 - 1.3)
20–39	2	355	0	0.30 (0.25 - 0.35)	0.085 (0.061 - 0.11)	0.28 (0.22 - 0.33)	0.58 (0.42 - 0.74)	2.2 (1.5 - 3.0)
40–59	2	359	0	0.30 (0.25 - 0.37)	0.066^{E} (0.037 - 0.095)	0.25 (0.18 - 0.31)	0.57^{E} (0.19 - 0.95)	3.3 (2.4 - 4.2)
60–79	2	287	0	0.21 (0.18 - 0.25)	0.054 (0.043 - 0.064)	0.18 (0.15 - 0.20)	0.40 (0.27 - 0.53)	2.3^{E} (1.2 - 3.3)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.5.1.2

2-Hydroxyfluorene — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1268	0	0.32 (0.27 - 0.38)	0.087 (0.071 - 0.10)	0.27 (0.23 - 0.32)	0.59 (0.42 - 0.76)	3.0 (2.1 - 4.0)
Males, 6–11	2	261	0	0.22 (0.18 - 0.27)	0.089 (0.071 - 0.11)	0.24 (0.19 - 0.29)	0.32 (0.23 - 0.42)	0.50 (0.42 - 0.58)
Males, 12–19	2	255	0	0.27 (0.23 - 0.32)	0.099 (0.078 - 0.12)	0.26 (0.22 - 0.30)	0.41 (0.32 - 0.50)	1.2 (0.84 - 1.5)
Males, 20–39	2	166	0	0.35 (0.27 - 0.45)	0.091 (0.059 - 0.12)	0.33^{E} (0.17 - 0.49)	0.66 (0.46 - 0.86)	x
Males, 40–59	2	193	0	0.41 (0.29 - 0.57)	F	0.32^{E} (0.11 - 0.53)	1.1^{E} (0.45 - 1.7)	x
Males, 60–79	2	142	0	0.25 (0.19 - 0.32)	0.080 (0.054 - 0.11)	0.20 (0.17 - 0.22)	0.39^{E} (0.23 - 0.56)	x
Females, Total 3–79	2	1256	0	0.22 (0.21 - 0.25)	0.064 (0.051 - 0.076)	0.21 (0.17 - 0.26)	0.38 (0.33 - 0.43)	1.8 (1.3 - 2.3)
Females, 6–11	2	250	0	0.21 (0.18 - 0.25)	0.086 (0.065 - 0.11)	0.23 (0.16 - 0.30)	0.34 (0.31 - 0.38)	0.74^{E} (0.43 - 1.1)
Females, 12–19	2	251	0	0.25 (0.21 - 0.30)	0.083^{E} (0.046 - 0.12)	0.26 (0.20 - 0.32)	0.45 (0.32 - 0.58)	0.80^{E} (0.50 - 1.1)
Females, 20–39	2	189	0	0.26 (0.21 - 0.32)	0.074^{E} (0.035 - 0.11)	0.26 (0.20 - 0.32)	0.43 (0.31 - 0.54)	x
Females, 40–59	2	166	0	0.22 (0.17 - 0.30)	0.066^{E} (0.033 - 0.099)	0.18^{E} (0.10 - 0.25)	0.35 (0.24 - 0.45)	x
Females, 60–79	2	145	0	0.18 (0.14 - 0.24)	0.041^{E} (0.023 - 0.059)	0.14 (0.098 - 0.19)	0.43^{E} (0.14 - 0.71)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.5.1.3

2-Hydroxyfluorene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (μg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2514	0	0.27 (0.24 - 0.29)	0.11 (0.094 - 0.12)	0.21 (0.20 - 0.23)	0.37 (0.31 - 0.42)	2.0 (1.5 - 2.5)
3–5	2	505	0	0.31 (0.27 - 0.34)	0.16 (0.14 - 0.18)	0.30 (0.27 - 0.34)	0.42 (0.35 - 0.48)	0.75 (0.63 - 0.88)
6–11	2	509	0	0.25 (0.22 - 0.28)	0.15 (0.13 - 0.16)	0.23 (0.19 - 0.26)	0.33 (0.27 - 0.40)	0.59 (0.41 - 0.77)
12–19	2	504	0	0.20 (0.18 - 0.22)	0.10 (0.089 - 0.11)	0.18 (0.16 - 0.19)	0.27 (0.22 - 0.31)	F
20–39	2	353	0	0.27 (0.22 - 0.33)	0.11 (0.082 - 0.13)	0.21 (0.17 - 0.24)	0.38 (0.26 - 0.50)	2.3^{E} (1.0 - 3.7)
40–59	2	357	0	0.30 (0.26 - 0.36)	0.11 (0.084 - 0.13)	0.22 (0.18 - 0.26)	0.43^{E} (0.16 - 0.70)	2.4 (1.6 - 3.3)
60–79	2	286	0	0.25 (0.22 - 0.28)	0.099 (0.090 - 0.11)	0.19 (0.17 - 0.21)	0.30^{E} (0.17 - 0.43)	1.8 (1.3 - 2.2)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 16.5.1.4

2-Hydroxyfluorene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1264	0	0.27 (0.23 - 0.32)	0.097 (0.086 - 0.11)	0.21 (0.18 - 0.24)	0.40 (0.29 - 0.51)	2.4^{E} (1.3 - 3.5)
Males, 6–11	2	260	0	0.25 (0.21 - 0.30)	0.14 (0.11 - 0.17)	0.24 (0.19 - 0.28)	0.32 (0.24 - 0.40)	0.51^{E} (0.28 - 0.75)
Males, 12–19	2	254	0	0.19 (0.17 - 0.22)	0.096 (0.084 - 0.11)	0.17 (0.15 - 0.19)	0.26 (0.19 - 0.34)	0.58^{E} (0.24 - 0.92)
Males, 20–39	2	165	0	0.27 (0.19 - 0.37)	0.088 (0.064 - 0.11)	0.20 (0.14 - 0.25)	F	x
Males, 40–59	2	193	0	0.35 (0.27 - 0.45)	0.099 (0.080 - 0.12)	0.25^{E} (0.11 - 0.39)	F	x
Males, 60–79	2	142	0	0.23 (0.18 - 0.30)	0.097 (0.082 - 0.11)	0.18 (0.14 - 0.21)	0.27^{E} (0.13 - 0.41)	x
Females, Total 3–79	2	1250	0	0.26 (0.24 - 0.28)	0.12 (0.11 - 0.13)	0.21 (0.20 - 0.23)	0.35 (0.29 - 0.40)	1.7 (1.3 - 2.1)
Females, 6–11	2	249	0	0.25 (0.23 - 0.28)	0.15 (0.13 - 0.17)	0.22 (0.20 - 0.25)	0.33 (0.28 - 0.38)	0.65 (0.46 - 0.85)
Females, 12–19	2	250	0	0.21 (0.17 - 0.25)	0.11 (0.099 - 0.13)	0.18 (0.15 - 0.20)	0.27 (0.21 - 0.33)	F
Females, 20–39	2	188	0	0.27 (0.23 - 0.31)	0.12 (0.11 - 0.14)	0.21 (0.17 - 0.25)	0.38 (0.26 - 0.50)	x
Females, 40–59	2	164	0	0.26 (0.21 - 0.33)	0.12 (0.086 - 0.16)	0.21 (0.19 - 0.23)	0.30 (0.22 - 0.37)	x
Females, 60–79	2	144	0	0.27 (0.22 - 0.32)	0.10 (0.093 - 0.11)	0.19 (0.16 - 0.22)	0.44^{E} (0.19 - 0.70)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

16.5.2 3-Hydroxyfluorene

Table 16.5.2.1

3-Hydroxyfluorene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2523	0.04	0.096 (0.086 - 0.11)	0.022 (0.020 - 0.025)	0.081 (0.072 - 0.089)	0.18 (0.15 - 0.21)	1.3 (0.96 - 1.7)
3–5	2	507	0	0.069 (0.063 - 0.077)	0.025 (0.020 - 0.030)	0.071 (0.061 - 0.080)	0.10 (0.091 - 0.12)	0.23^{E} (0.099 - 0.37)
6–11	2	511	0	0.084 (0.069 - 0.10)	0.033 (0.028 - 0.038)	0.087 (0.066 - 0.11)	0.14 (0.099 - 0.19)	0.26 (0.19 - 0.32)
12–19	2	506	0.20	0.093 (0.082 - 0.11)	0.029 (0.022 - 0.036)	0.093 (0.081 - 0.11)	0.16 (0.14 - 0.18)	0.53^{E} (0.33 - 0.73)
20–39	2	354	0	0.11 (0.092 - 0.13)	0.025 (0.018 - 0.032)	0.10 (0.079 - 0.12)	0.19 (0.15 - 0.24)	1.1^{E} (0.70 - 1.5)
40–59	2	358	0	0.11 (0.089 - 0.14)	0.020^{E} (0.011 - 0.030)	0.080 (0.062 - 0.099)	F	2.2 (1.5 - 3.0)
60–79	2	287	0	0.067 (0.056 - 0.080)	0.018 (0.014 - 0.022)	0.050 (0.043 - 0.057)	0.12^{E} (0.068 - 0.17)	1.1^{E} (0.58 - 1.7)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 16.5.2.2

3-Hydroxyfluorene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1266	0	0.12 (0.098 - 0.14)	0.028 (0.024 - 0.032)	0.096 (0.080 - 0.11)	0.22[E] (0.10 - 0.34)	1.7[E] (1.1 - 2.3)
Males, 6–11	2	261	0	0.088 (0.069 - 0.11)	0.035 (0.027 - 0.044)	0.087 (0.062 - 0.11)	0.15[E] (0.096 - 0.20)	0.23 (0.18 - 0.27)
Males, 12–19	2	255	0	0.10 (0.087 - 0.12)	0.032 (0.023 - 0.041)	0.099 (0.081 - 0.12)	0.16 (0.14 - 0.19)	0.62 (0.40 - 0.83)
Males, 20–39	2	165	0	0.13 (0.10 - 0.18)	0.031[E] (0.018 - 0.043)	0.11[E] (0.064 - 0.15)	0.26[E] (0.096 - 0.43)	x
Males, 40–59	2	192	0	0.16[E] (0.11 - 0.24)	F	0.12[E] (0.036 - 0.19)	0.50[E] (0.16 - 0.85)	x
Males, 60–79	2	142	0	0.078 (0.058 - 0.10)	0.023 (0.017 - 0.028)	0.060 (0.045 - 0.074)	0.11[E] (0.035 - 0.19)	x
Females, Total 3–79	2	1257	0.08	0.078 (0.070 - 0.086)	0.019 (0.015 - 0.023)	0.071 (0.058 - 0.083)	0.14 (0.10 - 0.18)	0.99[E] (0.59 - 1.4)
Females, 6–11	2	250	0	0.080 (0.065 - 0.098)	0.029 (0.023 - 0.036)	0.085 (0.062 - 0.11)	0.12[E] (0.078 - 0.17)	0.30 (0.20 - 0.39)
Females, 12–19	2	251	0.40	0.084 (0.067 - 0.10)	0.023[E] (0.013 - 0.034)	0.088 (0.072 - 0.10)	0.16 (0.11 - 0.21)	0.37[E] (0.17 - 0.56)
Females, 20–39	2	189	0	0.091 (0.071 - 0.12)	0.023[E] (0.011 - 0.035)	0.097 (0.065 - 0.13)	0.17 (0.12 - 0.22)	x
Females, 40–59	2	166	0	0.078 (0.057 - 0.11)	0.020[E] (0.0076 - 0.033)	0.062 (0.044 - 0.081)	0.12[E] (0.056 - 0.18)	x
Females, 60–79	2	145	0	0.058 (0.043 - 0.077)	0.014[E] (0.0076 - 0.019)	0.048 (0.031 - 0.064)	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.5.2.3

3-Hydroxyfluorene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2513	0.04	0.096 (0.087 - 0.11)	0.032 (0.031 - 0.034)	0.070 (0.063 - 0.077)	0.14 (0.12 - 0.16)	1.1 (0.90 - 1.4)
3–5	2	506	0	0.12 (0.11 - 0.14)	0.062 (0.057 - 0.066)	0.11 (0.096 - 0.13)	0.17 (0.14 - 0.20)	0.32[E] (0.16 - 0.49)
6–11	2	509	0	0.098 (0.085 - 0.11)	0.050 (0.043 - 0.057)	0.094 (0.079 - 0.11)	0.14 (0.11 - 0.16)	0.26 (0.20 - 0.32)
12–19	2	504	0.20	0.072 (0.062 - 0.083)	0.031 (0.027 - 0.036)	0.063 (0.055 - 0.070)	0.10 (0.082 - 0.12)	F
20–39	2	352	0	0.099 (0.080 - 0.12)	0.033 (0.027 - 0.039)	0.070 (0.057 - 0.083)	0.15 (0.096 - 0.20)	1.1[E] (0.49 - 1.7)
40–59	2	356	0	0.11 (0.091 - 0.14)	0.033 (0.028 - 0.038)	0.073 (0.052 - 0.094)	F	1.6 (1.2 - 2.1)
60–79	2	286	0	0.078 (0.067 - 0.091)	0.028 (0.025 - 0.031)	0.056 (0.047 - 0.064)	0.098[E] (0.059 - 0.14)	0.97 (0.80 - 1.1)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 16.5.2.4

3-Hydroxyfluorene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1262	0	0.10 (0.086 - 0.12)	0.032 (0.029 - 0.034)	0.075 (0.060 - 0.089)	0.16^{E} (0.085 - 0.23)	1.4^{E} (0.89 - 2.0)
Males, 6–11	2	260	0	0.10 (0.082 - 0.12)	0.049 (0.034 - 0.063)	0.096 (0.074 - 0.12)	0.14 (0.11 - 0.17)	0.25^{E} (0.13 - 0.37)
Males, 12–19	2	254	0	0.074 (0.064 - 0.085)	0.029 (0.023 - 0.035)	0.063 (0.054 - 0.071)	0.11 (0.081 - 0.13)	0.33^{E} (0.20 - 0.45)
Males, 20–39	2	164	0	0.10^{E} (0.072 - 0.15)	0.031 (0.026 - 0.035)	0.068^{E} (0.039 - 0.096)	F	x
Males, 40–59	2	192	0	0.14 (0.097 - 0.19)	0.032 (0.028 - 0.037)	0.095^{E} (0.049 - 0.14)	F	x
Males, 60–79	2	142	0	0.073 (0.054 - 0.098)	0.028 (0.024 - 0.032)	0.051 (0.043 - 0.060)	F	x
Females, Total 3–79	2	1251	0.08	0.089 (0.081 - 0.099)	0.035 (0.032 - 0.039)	0.069 (0.063 - 0.075)	0.13 (0.11 - 0.15)	0.99 (0.71 - 1.3)
Females, 6–11	2	249	0	0.096 (0.084 - 0.11)	0.052 (0.043 - 0.061)	0.088 (0.071 - 0.11)	0.13 (0.11 - 0.15)	0.26 (0.18 - 0.34)
Females, 12–19	2	250	0.40	0.069 (0.055 - 0.088)	0.033 (0.028 - 0.038)	0.063 (0.051 - 0.075)	0.091 (0.066 - 0.12)	F
Females, 20–39	2	188	0	0.094 (0.079 - 0.11)	0.039 (0.030 - 0.049)	0.070 (0.057 - 0.083)	0.15 (0.098 - 0.20)	x
Females, 40–59	2	164	0	0.092 (0.072 - 0.12)	0.038 (0.029 - 0.046)	0.068 (0.061 - 0.076)	0.12 (0.087 - 0.15)	x
Females, 60–79	2	144	0	0.083 (0.067 - 0.10)	0.031 (0.025 - 0.038)	0.060 (0.046 - 0.075)	0.12^{E} (0.058 - 0.19)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

16.5.3 9-Hydroxyfluorene

Table 16.5.3.1

9-Hydroxyfluorene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2514	0	0.16 (0.15 - 0.17)	0.051 (0.045 - 0.058)	0.16 (0.14 - 0.17)	0.26 (0.22 - 0.29)	0.66 (0.57 - 0.76)
3–5	2	505	0	0.098 (0.088 - 0.11)	0.040 (0.032 - 0.048)	0.098 (0.086 - 0.11)	0.15 (0.13 - 0.18)	0.30 (0.25 - 0.34)
6–11	2	509	0	0.11 (0.091 - 0.13)	0.042 (0.032 - 0.051)	0.11 (0.086 - 0.13)	0.17 (0.12 - 0.22)	0.38 (0.28 - 0.47)
12–19	2	501	0	0.15 (0.13 - 0.17)	0.060 (0.047 - 0.073)	0.14 (0.12 - 0.17)	0.23 (0.19 - 0.28)	0.49 (0.35 - 0.62)
20–39	2	355	0	0.17 (0.15 - 0.20)	0.058 (0.041 - 0.076)	0.18 (0.15 - 0.21)	0.27 (0.19 - 0.35)	0.66 (0.53 - 0.79)
40–59	2	358	0	0.17 (0.15 - 0.20)	0.048^{E} (0.029 - 0.066)	0.17 (0.13 - 0.20)	0.30 (0.24 - 0.35)	0.80 (0.55 - 1.1)
60–79	2	286	0	0.16 (0.14 - 0.18)	0.052 (0.046 - 0.058)	0.15 (0.13 - 0.17)	0.27 (0.20 - 0.34)	0.73^{E} (0.46 - 1.0)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.5.3.2

9-Hydroxyfluorene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1260	0	0.17 (0.15 - 0.20)	0.057 (0.048 - 0.066)	0.17 (0.13 - 0.20)	0.29 (0.22 - 0.37)	0.73 (0.61 - 0.85)
Males, 6–11	2	259	0	0.11 (0.087 - 0.14)	0.041 (0.034 - 0.048)	0.11 (0.074 - 0.14)	0.18^{E} (0.12 - 0.25)	0.37 (0.27 - 0.48)
Males, 12–19	2	251	0	0.15 (0.13 - 0.17)	0.059 (0.041 - 0.077)	0.14 (0.12 - 0.17)	0.22 (0.18 - 0.26)	0.58 (0.39 - 0.77)
Males, 20–39	2	166	0	0.19 (0.15 - 0.24)	0.057^{E} (0.016 - 0.097)	0.19 (0.16 - 0.23)	F	x
Males, 40–59	2	193	0	0.20 (0.16 - 0.25)	0.065 (0.046 - 0.083)	0.20 (0.14 - 0.27)	0.37 (0.27 - 0.46)	x
Males, 60–79	2	141	0	0.18 (0.15 - 0.23)	0.064^{E} (0.038 - 0.091)	0.16 (0.12 - 0.20)	0.30 (0.20 - 0.41)	x
Females, Total 3–79	2	1254	0	0.15 (0.13 - 0.16)	0.048 (0.040 - 0.055)	0.14 (0.13 - 0.16)	0.24 (0.22 - 0.27)	0.49 (0.32 - 0.66)
Females, 6–11	2	250	0	0.11 (0.092 - 0.13)	0.047 (0.033 - 0.060)	0.11 (0.088 - 0.13)	0.16 (0.11 - 0.20)	0.40^{E} (0.21 - 0.60)
Females, 12–19	2	250	0	0.14 (0.12 - 0.17)	0.060 (0.041 - 0.079)	0.14 (0.12 - 0.17)	0.25 (0.19 - 0.30)	0.45 (0.38 - 0.51)
Females, 20–39	2	189	0	0.16 (0.14 - 0.19)	0.058^{E} (0.031 - 0.086)	0.16 (0.12 - 0.21)	0.27 (0.20 - 0.34)	x
Females, 40–59	2	165	0	0.15 (0.11 - 0.20)	0.045^{E} (0.023 - 0.066)	0.15 (0.11 - 0.19)	0.24 (0.19 - 0.29)	x
Females, 60–79	2	145	0	0.14 (0.11 - 0.17)	0.048 (0.039 - 0.057)	0.13^{E} (0.074 - 0.18)	0.24 (0.18 - 0.30)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.5.3.3

9-Hydroxyfluorene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2504	0	0.16 (0.15 - 0.17)	0.060 (0.053 - 0.066)	0.15 (0.14 - 0.16)	0.26 (0.22 - 0.29)	0.62 (0.52 - 0.73)
3–5	2	504	0	0.17 (0.15 - 0.19)	0.068 (0.053 - 0.083)	0.18 (0.15 - 0.20)	0.26 (0.22 - 0.31)	0.62 (0.42 - 0.81)
6–11	2	507	0	0.13 (0.11 - 0.15)	0.057 (0.050 - 0.065)	0.12 (0.095 - 0.14)	0.20 (0.16 - 0.25)	0.43^{E} (0.21 - 0.65)
12–19	2	499	0	0.11 (0.097 - 0.13)	0.048 (0.039 - 0.057)	0.11 (0.086 - 0.13)	0.17 (0.14 - 0.20)	0.37^{E} (0.16 - 0.58)
20–39	2	353	0	0.15 (0.13 - 0.18)	0.059 (0.049 - 0.070)	0.14 (0.12 - 0.16)	0.24 (0.17 - 0.31)	0.56 (0.39 - 0.73)
40–59	2	356	0	0.17 (0.16 - 0.19)	0.064 (0.055 - 0.073)	0.16 (0.14 - 0.19)	0.29 (0.22 - 0.35)	0.64^{E} (0.39 - 0.88)
60–79	2	285	0	0.19 (0.16 - 0.22)	0.065 (0.043 - 0.087)	0.17 (0.13 - 0.20)	0.30 (0.23 - 0.37)	0.77 (0.56 - 0.99)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.5.3.4

9-Hydroxyfluorene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], *Canadian Health Measures Survey* cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1256	0	0.15 (0.13 - 0.17)	0.055 (0.046 - 0.065)	0.13 (0.12 - 0.15)	0.25 (0.19 - 0.31)	0.62 (0.50 - 0.74)
Males, 6–11	2	258	0	0.12 (0.099 - 0.16)	0.057 (0.045 - 0.069)	0.11 (0.077 - 0.14)	0.20 (0.14 - 0.26)	0.43 (0.30 - 0.55)
Males, 12–19	2	250	0	0.11 (0.093 - 0.12)	0.043 (0.033 - 0.053)	0.10 (0.086 - 0.12)	0.15 (0.13 - 0.18)	0.31[E] (0.13 - 0.49)
Males, 20–39	2	165	0	0.14 (0.11 - 0.17)	0.055 (0.041 - 0.070)	0.11 (0.078 - 0.14)	0.24[E] (0.11 - 0.37)	x
Males, 40–59	2	193	0	0.17 (0.15 - 0.20)	0.058 (0.043 - 0.074)	0.16 (0.11 - 0.20)	0.29 (0.21 - 0.37)	x
Males, 60–79	2	141	0	0.17 (0.13 - 0.22)	0.060[E] (0.020 - 0.10)	0.15 (0.12 - 0.17)	0.28 (0.19 - 0.37)	x
Females, Total 3–79	2	1248	0	0.17 (0.15 - 0.19)	0.065 (0.058 - 0.072)	0.16 (0.14 - 0.18)	0.26 (0.22 - 0.30)	0.62 (0.45 - 0.80)
Females, 6–11	2	249	0	0.13 (0.12 - 0.15)	0.057 (0.048 - 0.067)	0.12 (0.10 - 0.14)	0.22 (0.17 - 0.26)	F
Females, 12–19	2	249	0	0.12 (0.098 - 0.15)	0.052 (0.045 - 0.060)	0.12 (0.084 - 0.16)	0.20 (0.16 - 0.23)	0.51[E] (0.28 - 0.74)
Females, 20–39	2	188	0	0.17 (0.14 - 0.20)	0.077 (0.055 - 0.10)	0.15 (0.12 - 0.19)	0.24 (0.18 - 0.31)	x
Females, 40–59	2	163	0	0.18 (0.14 - 0.23)	0.062 (0.045 - 0.079)	0.17 (0.14 - 0.21)	0.28[E] (0.17 - 0.39)	x
Females, 60–79	2	144	0	0.20 (0.17 - 0.24)	0.066 (0.046 - 0.086)	0.19 (0.15 - 0.23)	0.34 (0.24 - 0.44)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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16.6 NAPHTHALENE METABOLITES

Naphthalene is a polycyclic aromatic hydrocarbon (PAH) with two fused benzene rings. Naphthalene is manufactured and imported into Canada for a wide variety of industrial uses (Environment Canada & Health Canada, 2008). The major consumer products made from naphthalene are moth repellents, in the form of mothballs or crystals, and toilet deodorant blocks. Other commercial use of naphthalene include components of polyvinyl chloride phthalate plasticizers, dyes, resins, leather-tanning agents, and the insecticide carbaryl (EPA, 2008; IARC, 2002).

Naphthalene evaporates easily and is often found in the gaseous phase in ambient air (WHO, 2010). Although diet and smoking are the most important sources of intake for most PAHs, inhalation of ambient and indoor air is the main source of naphthalene exposure for the general population. In Canada, indoor air exposure accounts for more than 95% of the total daily exposure across age groups (Environment Canada & Health Canada, 2008). A recent study identified mothballs and some building materials and furnishings (vinyl and wooden furniture, and painted walls and ceilings) as significant contributors to indoor naphthalene concentrations in Canadian homes (Kang et al., 2012). Other sources of naphthalene in indoor and ambient air include migration of volatile organic compounds from attached garages, during cooking, and from kerosene space heaters and wood stoves (Batterman et al., 2007; Environment Canada & Health Canada, 2008). Food and drinking water are considered minor sources of exposure to naphthalene (NTP, 2002).

Naphthalene is rapidly absorbed and metabolized following oral and inhalation exposures in laboratory animals (Bagchi et al., 2002; NTP, 2002). Naphthalene is also absorbed following dermal application in humans and laboratory animals (Storer et al., 1984; Turkall et al., 1994). Like other PAHs, naphthalene undergoes multi-step metabolism, the result of which includes the production of the hydroxynaphthalene metabolites, 1- and 2-hydroxynaphthalene (WHO, 2010). Urinary levels of hydroxynaphthalene metabolites are reflective of recent exposure and have been measured in several human studies (Bouchard et al., 2009; CDC, 2009; Nethery et al., 2012). Urinary 2-hydroxynaphthalene is a unique biomarker of naphthalene metabolism (CDC, 2009). 1-Hydroxynaphthalene is a metabolite of both naphthalene and the insecticide carbaryl, making it difficult to distinguish between these exposures in the general population. For more information on carbaryl, see section 14.2 (Carbamate Metabolites).

In humans, the most serious effects of acute exposure to naphthalene are reported in individuals with glucose 6-phosphate dehydrogenase deficiency, where hemolytic anemia is the primary adverse effect (WHO, 2010). Reports from occupational exposure and animal studies suggest chronic exposure to naphthalene may lead to the development of lens opacities such as cataracts (WHO, 2010). Respiratory tract lesions have also been observed in laboratory animals following acute and chronic exposures (WHO, 2010). Naphthalene has been observed to induce airway tumours in laboratory animals (NTP, 2002). Increased cell proliferation due to cytotoxicity (cell damage) is considered a key element in the development of airway tumours (WHO, 2010). The International Agency for Research on Cancer has classified naphthalene as Group 2B, possibly carcinogenic to humans (IARC, 2002). The carcinogenicity of naphthalene has been proposed to involve non-genotoxic mechanisms (IARC, 2002). Considering the apparent non-genotoxicity of naphthalene, the World Health Organization favours the assumption of the existence of a threshold and has derived an annual average indoor air guideline for naphthalene (WHO, 2010). The guideline is considered to protect against the carcinogenic and non-carcinogenic effects to the respiratory tract resulting from naphthalene exposure.

On the basis of carcinogenicity as well as non-cancer effects, Health Canada and Environment Canada have concluded that naphthalene is a concern for human health (Environment Canada & Health Canada, 2008). As a result, naphthalene is listed as a toxic substance on Schedule 1 of the *Canadian Environmental Protection Act, 1999* (Canada, 1999; Canada, 2010a). In an effort to reduce exposure to naphthalene, several risk management approaches have been taken (Canada, 2010b). In 2010, the Pest Management Regulatory Agency (PMRA) re-evaluated the insecticidal uses of naphthalene. PMRA concluded that pest control products containing naphthalene do not present unacceptable risks to human health when used according to label directions and has granted continued registration (Health Canada, 2010). Health Canada has introduced new packaging and labelling requirements for naphthalene-containing consumer products (mothballs and moth flakes) in order to minimize exposure (Health Canada, 2012). Naphthalene, 1- hydroxynaphthalene and its salts, and 2-hydroxynaphthalene are all included on Health Canada's list of prohibited and restricted cosmetic ingredients (also known as the Cosmetic Ingredient Hotlist). The Hotlist is an administrative tool to communicate to manufacturers and others that substances on the Hotlist, if used in cosmetics, may cause injury to the health of the user, which is in contravention of the general prohibition against the sale of unsafe cosmetics in the *Food and Drugs Act* (Canada, 1985; Health Canada, 2011). The Government of Canada is also investigating the development of air quality guidelines for naphthalene levels in residential indoor air (Canada, 2010b).

1-Hydroxynaphthalene and 2-hydroxynaphthalene have been measured in urine as biomarkers of exposure to naphthalene in several studies. In 1999, a study measured the urinary hydroxynaphthalene metabolite concentrations in 60 non-smoking and non-occupational exposed adults (30 exposed and 30 control individuals) between the ages of 18 and 60 years living in the vicinity of a creosote impregnation plant in Delson, Quebec (Bouchard et al., 2001). The geometric means urinary concentrations in residents living near the plant were 3.17 µg/g creatinine for 1-hydroxynaphthalene and 2.47 µg/g creatinine for 2-hydroxynaphthalene. In the control group, geometric mean concentrations were 1.49 µg/g creatinine and 1.38 µg/g creatinine for 1-hydroxynaphthalene and 2-hydroxynaphthalene, respectively (Bouchard et al., 2001). In 144 residents aged 16 to 64 years living near an aluminum plant in Baie-Comeau, Quebec, the geometric mean concentrations ranged from 0.80 to 2.17 µg/g creatinine for 1-hydroxynaphthalene and 1.75 to 3.26 µg/g creatinine for 2-hydroxynaphthalene (Bouchard et al., 2009).

Naphthalene metabolites, 1-hydroxynaphthalene and 2-hydroxynaphthalene, were measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and are presented as both µg/L and µg/g creatinine (Tables 16.6.1.1 to 16.6.2.4). Finding a measurable amount of naphthalene metabolites in urine can be an indicator of exposure to naphthalene or carbaryl (for 1-hydroxynaphthalene) and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary naphthalene metabolites in the Canadian population.

16.6.1 1-Hydroxynaphthalene

Table 16.6.1.1

1-Hydroxynaphthalene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2522	0.79	1.5 (1.3 - 1.7)	0.27 (0.18 - 0.37)	1.3 (1.1 - 1.5)	2.9 (2.4 - 3.4)	15 (12 - 19)
3–5	2	506	0.40	1.4 (1.2 - 1.6)	0.43 (0.35 - 0.50)	1.2 (1.0 - 1.4)	2.8 (2.3 - 3.4)	F
6–11	2	511	0.39	0.95 (0.78 - 1.2)	0.25[E] (<LOD - 0.40)	0.92 (0.73 - 1.1)	1.6 (1.2 - 2.1)	4.0 (2.9 - 5.2)
12–19	2	505	1.39	1.2 (0.97 - 1.4)	0.28[E] (0.14 - 0.41)	1.0 (0.83 - 1.2)	2.1 (1.8 - 2.5)	F
20–39	2	354	1.13	1.4 (1.1 - 1.7)	0.29[E] (0.14 - 0.43)	1.4 (1.0 - 1.7)	2.8 (2.0 - 3.6)	13 (9.9 - 15)
40–59	2	359	1.11	1.7 (1.3 - 2.2)	0.28[E] (0.11 - 0.44)	1.3 (0.97 - 1.7)	3.9[E] (1.6 - 6.3)	19[E] (11 - 27)
60–79	2	287	0.35	1.7 (1.3 - 2.2)	0.25[E] (0.12 - 0.39)	1.6 (1.2 - 1.9)	3.3 (2.2 - 4.4)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 16.6.1.2

1-Hydroxynaphthalene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1267	0.39	1.6 (1.3 - 2.0)	0.29[E] (0.16 - 0.42)	1.3 (1.0 - 1.7)	3.7 (2.4 - 5.0)	17 (13 - 21)
Males, 6–11	2	261	0.38	0.98 (0.78 - 1.2)	0.28[E] (<LOD - 0.48)	0.89 (0.63 - 1.2)	1.6[E] (1.0 - 2.2)	3.7[E] (1.8 - 5.6)
Males, 12–19	2	255	0.78	1.1 (0.90 - 1.4)	0.29[E] (0.13 - 0.44)	0.98 (0.75 - 1.2)	2.0 (1.5 - 2.5)	F
Males, 20–39	2	166	0	1.6 (1.2 - 2.0)	0.37[E] (0.22 - 0.52)	1.4 (0.95 - 1.9)	4.0[E] (1.6 - 6.3)	x
Males, 40–59	2	193	0	2.0[E] (1.3 - 2.9)	0.29[E] (0.14 - 0.43)	F	F	x
Males, 60–79	2	142	0.70	1.8 (1.3 - 2.6)	F	1.6[E] (0.83 - 2.4)	3.7[E] (1.5 - 6.0)	x
Females, Total 3–79	2	1255	1.20	1.4 (1.2 - 1.6)	0.26[E] (0.14 - 0.37)	1.2 (1.1 - 1.4)	2.5 (2.0 - 2.9)	F
Females, 6–11	2	250	0.40	0.92 (0.72 - 1.2)	F	0.94 (0.70 - 1.2)	1.5 (1.2 - 1.9)	4.4 (3.3 - 5.6)
Females, 12–19	2	250	2.00	1.2 (0.97 - 1.5)	0.26[E] (<LOD - 0.43)	1.1 (0.86 - 1.3)	2.2[E] (1.4 - 3.0)	F
Females, 20–39	2	188	2.13	1.3 (0.97 - 1.6)	F	1.2[E] (0.71 - 1.7)	2.6 (2.2 - 3.1)	x
Females, 40–59	2	166	2.41	1.5[E] (0.99 - 2.1)	F	1.3 (0.94 - 1.6)	2.5[E] (0.90 - 4.1)	x
Females, 60–79	2	145	0	1.6[E] (0.98 - 2.7)	0.24[E] (<LOD - 0.41)	1.5 (0.97 - 2.0)	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.6.1.3

1-Hydroxynaphthalene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2512	0.80	1.5 (1.3 - 1.7)	0.33 (0.23 - 0.42)	1.3 (1.1 - 1.5)	2.8 (2.3 - 3.3)	15 (12 - 19)
3–5	2	505	0.40	2.5 (2.2 - 2.9)	0.75 (0.54 - 0.95)	2.2 (1.9 - 2.6)	4.6 (3.9 - 5.4)	15[E] (5.8 - 25)
6–11	2	509	0.39	1.1 (0.91 - 1.3)	0.36[E] (<LOD - 0.49)	1.0 (0.84 - 1.2)	1.9 (1.3 - 2.5)	4.9 (3.4 - 6.5)
12–19	2	503	1.39	0.90 (0.75 - 1.1)	0.27 (0.18 - 0.35)	0.84 (0.72 - 0.95)	1.5 (1.2 - 1.8)	F
20–39	2	352	1.14	1.3 (0.96 - 1.7)	0.24[E] (0.15 - 0.33)	1.3[E] (0.79 - 1.8)	2.6[E] (1.6 - 3.6)	13[E] (7.1 - 19)
40–59	2	357	1.12	1.7 (1.3 - 2.2)	0.37[E] (0.19 - 0.55)	1.4[E] (0.80 - 1.9)	3.2[E] (1.0 - 5.4)	19[E] (9.8 - 27)
60–79	2	286	0.35	2.0 (1.6 - 2.6)	0.50 (0.36 - 0.65)	1.5 (1.2 - 1.8)	3.4[E] (2.1 - 4.7)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 16.6.1.4

1-Hydroxynaphthalene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1263	0.40	1.4 (1.1 - 1.7)	0.27 (0.17 - 0.36)	1.1 (0.89 - 1.4)	3.0[E] (1.7 - 4.2)	16 (12 - 20)
Males, 6–11	2	260	0.38	1.1 (0.85 - 1.5)	0.36[E] (<LOD - 0.56)	1.1 (0.89 - 1.3)	2.0[E] (1.2 - 2.7)	4.8[E] (1.9 - 7.7)
Males, 12–19	2	254	0.79	0.81 (0.66 - 1.0)	0.24[E] (0.14 - 0.34)	0.77 (0.60 - 0.95)	1.4 (1.0 - 1.7)	5.3[E] (2.1 - 8.6)
Males, 20–39	2	165	0	1.2 (0.88 - 1.7)	0.24[E] (0.15 - 0.32)	0.90[E] (0.57 - 1.2)	F	x
Males, 40–59	2	193	0	1.7[E] (1.2 - 2.4)	0.28[E] (0.13 - 0.43)	F	F	x
Males, 60–79	2	142	0.70	1.7 (1.3 - 2.3)	0.40[E] (<LOD - 0.62)	1.5 (1.1 - 1.9)	3.3[E] (1.2 - 5.4)	x
Females, Total 3–79	2	1249	1.20	1.6 (1.4 - 1.8)	0.40 (0.31 - 0.50)	1.4 (1.2 - 1.6)	2.7 (2.2 - 3.1)	F
Females, 6–11	2	249	0.40	1.1 (0.88 - 1.4)	0.34[E] (<LOD - 0.51)	0.96 (0.78 - 1.2)	1.8[E] (1.1 - 2.5)	5.2 (3.7 - 6.7)
Females, 12–19	2	249	2.01	1.0 (0.78 - 1.3)	0.31 (<LOD - 0.42)	0.88 (0.71 - 1.1)	1.8 (1.3 - 2.4)	F
Females, 20–39	2	187	2.14	1.3 (0.97 - 1.8)	0.28[E] (<LOD - 0.46)	1.4 (1.1 - 1.7)	2.7 (1.8 - 3.6)	x
Females, 40–59	2	164	2.44	1.7 (1.3 - 2.3)	0.46[E] (<LOD - 0.71)	1.5[E] (0.94 - 2.0)	2.6[E] (0.91 - 4.2)	x
Females, 60–79	2	144	0	2.4[E] (1.5 - 3.8)	0.71 (<LOD - 0.96)	1.5[E] (0.90 - 2.1)	F	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

16.6.2 2-Hydroxynaphthalene

Table 16.6.2.1

2-Hydroxynaphthalene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2503	0	3.8 (3.3 - 4.4)	0.84 (0.68 - 1.0)	3.8 (3.2 - 4.4)	8.9 (7.2 - 11)	24 (18 - 30)
3–5	2	499	0	3.3 (2.8 - 3.8)	1.1 (0.91 - 1.2)	3.0 (2.4 - 3.6)	6.0 (4.3 - 7.6)	17^{E} (8.9 - 24)
6–11	2	509	0	3.2 (2.6 - 4.0)	1.1 (0.82 - 1.3)	3.0 (2.3 - 3.8)	5.8 (4.4 - 7.2)	F
12–19	2	503	0	4.4 (3.8 - 5.1)	1.1 (0.93 - 1.3)	4.4 (3.5 - 5.3)	8.8 (7.1 - 11)	24 (19 - 29)
20–39	2	352	0	4.4 (3.5 - 5.5)	0.88^{E} (0.53 - 1.2)	4.8 (3.8 - 5.9)	9.9 (7.7 - 12)	22 (18 - 27)
40–59	2	354	0	4.1 (3.0 - 5.5)	0.75^{E} (0.27 - 1.2)	3.7^{E} (2.1 - 5.2)	10 (8.0 - 13)	31 (20 - 42)
60–79	2	286	0	2.8 (2.4 - 3.3)	0.58^{E} (0.31 - 0.86)	2.5 (1.9 - 3.2)	5.5 (3.8 - 7.2)	22 (19 - 26)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 16.6.2.2

2-Hydroxynaphthalene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1251	0	4.0 (3.3 - 4.9)	0.99 (0.81 - 1.2)	3.9 (3.1 - 4.8)	8.7 (6.4 - 11)	26 (19 - 32)
Males, 6–11	2	260	0	3.3 (2.5 - 4.4)	1.0 (0.76 - 1.3)	3.5^{E} (2.1 - 4.9)	5.9^{E} (3.5 - 8.4)	F
Males, 12–19	2	252	0	4.1 (3.2 - 5.2)	1.2 (0.74 - 1.6)	4.1 (3.2 - 5.1)	6.7^{E} (3.6 - 9.9)	21^{E} (13 - 29)
Males, 20–39	2	164	0	4.1 (3.0 - 5.5)	1.1^{E} (0.52 - 1.6)	4.2 (2.7 - 5.6)	8.3 (5.4 - 11)	x
Males, 40–59	2	189	0	4.6^{E} (3.1 - 6.6)	0.95 (0.62 - 1.3)	4.2^{E} (1.8 - 6.6)	11^{E} (4.1 - 18)	x
Males, 60–79	2	141	0	3.3 (2.7 - 4.1)	0.81^{E} (0.41 - 1.2)	2.8 (2.0 - 3.5)	6.3^{E} (3.6 - 9.1)	x
Females, Total 3–79	2	1252	0	3.7 (3.2 - 4.3)	0.63^{E} (0.40 - 0.87)	3.5 (3.0 - 4.1)	9.2 (6.6 - 12)	23^{E} (13 - 32)
Females, 6–11	2	249	0	3.1 (2.5 - 3.9)	1.2 (0.91 - 1.4)	2.9 (2.2 - 3.6)	5.1 (3.4 - 6.9)	14^{E} (7.8 - 20)
Females, 12–19	2	251	0	4.7 (3.8 - 6.0)	1.1^{E} (0.66 - 1.6)	5.1 (3.8 - 6.3)	9.9 (8.6 - 11)	29^{E} (17 - 41)
Females, 20–39	2	188	0	4.8 (3.5 - 6.4)	0.76^{E} (0.42 - 1.1)	5.4 (4.0 - 6.9)	11 (7.5 - 15)	x
Females, 40–59	2	165	0	3.6^{E} (2.4 - 5.5)	F	3.4^{E} (2.0 - 4.8)	9.4^{E} (5.8 - 13)	x
Females, 60–79	2	145	0	2.4 (1.7 - 3.3)	F	2.3 (1.5 - 3.0)	4.3^{E} (2.3 - 6.2)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.6.2.3

2-Hydroxynaphthalene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2493	0	3.8 (3.4 - 4.3)	1.2 (1.1 - 1.3)	3.5 (2.9 - 4.0)	7.2 (5.8 - 8.6)	20 (17 - 22)
3–5	2	498	0	5.9 (5.1 - 6.8)	2.1 (2.0 - 2.3)	5.1 (4.2 - 5.9)	10 (6.8 - 14)	23^E (13 - 33)
6–11	2	507	0	3.8 (3.1 - 4.5)	1.6 (1.3 - 1.8)	3.7 (2.7 - 4.6)	6.0 (4.6 - 7.5)	12^E (5.5 - 19)
12–19	2	501	0	3.4 (3.0 - 3.9)	1.2 (1.1 - 1.3)	3.1 (2.6 - 3.6)	5.5 (4.6 - 6.4)	13 (11 - 16)
20–39	2	350	0	3.9 (3.3 - 4.7)	1.2 (1.0 - 1.4)	3.5 (2.5 - 4.4)	7.5 (5.7 - 9.4)	20 (15 - 24)
40–59	2	352	0	4.1 (3.3 - 5.2)	1.1^E (0.66 - 1.5)	3.8 (2.8 - 4.7)	8.2^E (3.9 - 13)	25 (19 - 31)
60–79	2	285	0	3.3 (2.9 - 3.7)	1.2 (1.1 - 1.3)	2.6 (2.2 - 3.1)	5.2 (4.2 - 6.2)	18 (15 - 20)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.6.2.4

2-Hydroxynaphthalene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1247	0	3.5 (2.9 - 4.1)	1.1 (0.98 - 1.2)	2.9 (2.3 - 3.5)	6.2 (4.1 - 8.4)	20 (14 - 25)
Males, 6–11	2	259	0	3.8 (3.0 - 4.7)	1.5 (1.1 - 1.8)	3.9 (2.6 - 5.2)	6.0 (3.8 - 8.1)	F
Males, 12–19	2	251	0	2.9 (2.4 - 3.6)	1.2 (1.0 - 1.3)	2.9 (2.6 - 3.2)	4.6 (3.2 - 6.1)	11 (8.5 - 13)
Males, 20–39	2	163	0	3.1 (2.3 - 4.2)	1.1 (0.90 - 1.3)	2.4 (1.8 - 3.0)	5.6^E (2.6 - 8.6)	x
Males, 40–59	2	189	0	3.9 (2.9 - 5.3)	1.0 (0.78 - 1.3)	3.5^E (1.8 - 5.3)	9.6^E (4.7 - 15)	x
Males, 60–79	2	141	0	3.1 (2.6 - 3.7)	1.1 (0.99 - 1.2)	2.6 (2.1 - 3.0)	5.3 (3.7 - 6.9)	x
Females, Total 3–79	2	1246	0	4.3 (3.9 - 4.6)	1.5 (1.2 - 1.7)	3.8 (3.3 - 4.3)	7.3 (6.0 - 8.7)	20 (17 - 24)
Females, 6–11	2	248	0	3.7 (3.1 - 4.5)	1.7 (1.4 - 2.1)	3.6 (2.4 - 4.8)	6.2 (4.6 - 7.8)	12^E (5.6 - 18)
Females, 12–19	2	250	0	3.9 (3.2 - 4.8)	1.3 (0.95 - 1.6)	3.9 (3.1 - 4.6)	6.4 (4.6 - 8.3)	F
Females, 20–39	2	187	0	4.9 (4.0 - 6.0)	1.5 (0.98 - 1.9)	5.0^E (2.8 - 7.2)	9.4^E (6.0 - 13)	x
Females, 40–59	2	163	0	4.3 (3.3 - 5.6)	1.6^E (<LOD - 2.4)	3.8 (3.0 - 4.5)	F	x
Females, 60–79	2	144	0	3.4 (2.8 - 4.3)	1.3 (0.99 - 1.6)	3.0 (2.2 - 3.8)	5.0^E (2.8 - 7.3)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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16.7 PHENANTHRENE METABOLITES

Phenanthrene is a polycyclic aromatic hydrocarbon (PAH) with three fused benzene rings. It is used in the manufacture of dyes, polymer materials, and biomedical research (Mondal et al., 2009).

After oral administration in rats, phenanthrene was found to be absorbed from the gastrointestinal tract (Faust, 1993). It is also absorbed through the skin in humans following dermal exposure (Storer et al., 1984). Metabolism of phenanthrene proceeds through the formation of epoxides that rearrange to form hydroxy and dihydrodiol metabolites (Jacob & Seidel, 2002). Phenanthrene metabolites are primarily excreted in the urine (Faust, 1993).

Urinary hydroxylated phenanthrene metabolites (1-, 2-, 3-, 4-, and 9-hydroxyphenanthrene) have been assessed in several biomonitoring studies and are indicators of recent PAH exposure (Becker et al., 2003; CDC, 2009; Jacob & Seidel, 2002; Nethery et al., 2012). Their relatively high abundance in the urine and the availability of validated analytical methods for their detection and quantification make them good biomarkers for assessing exposure. Additionally, urinary concentrations of monohydroxyphenanthrene metabolites are less sensitive to smoking status than other PAH metabolites; they are therefore better suited for assessing exposures where the study population comprises both smokers and non-smokers (Jacob et al., 1999; Rihs et al., 2005). Urinary 3-hydroxyphenanthrene may be a good predictive biomarker for specifically assessing inhalation exposure to phenanthrene (Nethery et al., 2012).

In animal studies, phenanthrene did not elicit systemic or carcinogenic effects (ATSDR, 1995). The International Agency for Research on Cancer has classified phenanthrene as Group 3, not classifiable as to its carcinogenicity in humans (IARC, 2010).

Phenanthrene metabolites, 1-, 2-, 3-, 4-, and 9-hydroxyphenanthrene, were measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and are presented as both µg/L and µg/g creatinine (Tables 16.7.1.1 to 16.7.5.4). Finding a measurable amount of phenanthrene metabolites in urine is an indicator of exposure to phenanthrene and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary phenanthrene metabolites in the Canadian population.

16.7.1 1-Hydroxyphenanthrene

Table 16.7.1.1

1-Hydroxyphenanthrene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2522	0.04	0.15 (0.14 - 0.17)	0.049 (0.042 - 0.056)	0.15 (0.14 - 0.17)	0.27 (0.23 - 0.30)	0.69 (0.53 - 0.84)
3–5	2	505	0	0.11 (0.097 - 0.13)	0.044 (0.037 - 0.051)	0.10 (0.094 - 0.12)	0.16 (0.13 - 0.20)	0.34 (0.26 - 0.42)
6–11	2	510	0	0.12 (0.11 - 0.14)	0.046 (0.039 - 0.054)	0.12 (0.097 - 0.14)	0.20 (0.16 - 0.24)	0.42 (0.32 - 0.51)
12–19	2	506	0	0.15 (0.14 - 0.17)	0.058 (0.044 - 0.073)	0.15 (0.13 - 0.18)	0.25 (0.22 - 0.28)	0.55 (0.43 - 0.67)
20–39	2	355	0	0.16 (0.13 - 0.18)	0.049 (0.033 - 0.066)	0.17 (0.15 - 0.19)	0.27 (0.19 - 0.36)	0.64[E] (0.41 - 0.87)
40–59	2	359	0	0.16 (0.14 - 0.19)	0.052[E] (0.031 - 0.073)	0.16 (0.12 - 0.19)	0.29 (0.24 - 0.33)	0.77 (0.58 - 0.97)
60–79	2	287	0.35	0.15 (0.13 - 0.17)	0.038 (0.026 - 0.050)	0.16 (0.13 - 0.18)	0.29 (0.22 - 0.35)	0.81 (0.53 - 1.1)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.7.1.2

1-Hydroxyphenanthrene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1268	0	0.16 (0.14 - 0.19)	0.054 (0.046 - 0.062)	0.16 (0.14 - 0.19)	0.28 (0.23 - 0.33)	0.73 (0.57 - 0.90)
Males, 6–11	2	261	0	0.12 (0.10 - 0.15)	0.046 (0.038 - 0.054)	0.12 (0.090 - 0.14)	0.18 (0.13 - 0.24)	0.39 (0.26 - 0.52)
Males, 12–19	2	255	0	0.15 (0.13 - 0.17)	0.059 (0.043 - 0.075)	0.15 (0.12 - 0.18)	0.24 (0.19 - 0.29)	0.47 (0.32 - 0.63)
Males, 20–39	2	166	0	0.16 (0.13 - 0.20)	0.051[E] (0.027 - 0.075)	0.17 (0.14 - 0.20)	0.29 (0.19 - 0.38)	x
Males, 40–59	2	193	0	0.19 (0.14 - 0.24)	0.060 (0.042 - 0.079)	0.19 (0.12 - 0.25)	0.30 (0.20 - 0.40)	x
Males, 60–79	2	142	0	0.17 (0.14 - 0.21)	0.055 (0.038 - 0.072)	0.15 (0.12 - 0.19)	0.28 (0.20 - 0.37)	x
Females, Total 3–79	2	1254	0.08	0.14 (0.13 - 0.16)	0.041 (0.032 - 0.049)	0.14 (0.12 - 0.16)	0.26 (0.21 - 0.30)	0.66[E] (0.40 - 0.92)
Females, 6–11	2	249	0	0.13 (0.11 - 0.15)	0.044 (0.031 - 0.058)	0.12 (0.095 - 0.14)	0.22 (0.17 - 0.27)	0.50[E] (0.22 - 0.78)
Females, 12–19	2	251	0	0.16 (0.13 - 0.19)	0.058[E] (0.036 - 0.081)	0.16 (0.11 - 0.20)	0.27 (0.21 - 0.32)	0.68[E] (0.43 - 0.94)
Females, 20–39	2	189	0	0.15 (0.13 - 0.18)	0.045[E] (0.023 - 0.067)	0.15 (0.11 - 0.20)	0.27[E] (0.15 - 0.39)	x
Females, 40–59	2	166	0	0.14 (0.11 - 0.19)	F	0.14 (0.10 - 0.17)	0.22[E] (0.12 - 0.32)	x
Females, 60–79	2	145	0.69	0.14 (0.11 - 0.17)	0.030 (0.021 - 0.040)	0.16[E] (0.099 - 0.22)	0.29 (0.20 - 0.39)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.7.1.3

1-Hydroxyphenanthrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2512	0.04	0.15 (0.14 - 0.16)	0.070 (0.064 - 0.075)	0.14 (0.13 - 0.16)	0.23 (0.21 - 0.26)	0.52 (0.42 - 0.63)
3–5	2	504	0	0.20 (0.17 - 0.22)	0.094 (0.074 - 0.11)	0.19 (0.16 - 0.21)	0.28 (0.23 - 0.33)	0.57 (0.38 - 0.75)
6–11	2	508	0	0.14 (0.13 - 0.16)	0.079 (0.071 - 0.087)	0.13 (0.11 - 0.14)	0.20 (0.17 - 0.23)	0.45^{E} (0.25 - 0.64)
12–19	2	504	0	0.12 (0.11 - 0.13)	0.060 (0.056 - 0.064)	0.11 (0.099 - 0.12)	0.15 (0.13 - 0.18)	0.32 (0.25 - 0.40)
20–39	2	353	0	0.14 (0.12 - 0.16)	0.057 (0.043 - 0.071)	0.13 (0.093 - 0.16)	0.22 (0.17 - 0.26)	0.49 (0.36 - 0.62)
40–59	2	357	0	0.17 (0.15 - 0.18)	0.078 (0.067 - 0.089)	0.15 (0.13 - 0.18)	0.24 (0.21 - 0.27)	0.58 (0.45 - 0.70)
60–79	2	286	0.35	0.18 (0.16 - 0.20)	0.075 (0.060 - 0.090)	0.16 (0.15 - 0.18)	0.27 (0.25 - 0.29)	0.63 (0.47 - 0.78)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.7.1.4

1-Hydroxyphenanthrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1264	0	0.14 (0.13 - 0.16)	0.061 (0.052 - 0.069)	0.13 (0.11 - 0.15)	0.22 (0.18 - 0.25)	0.52 (0.40 - 0.64)
Males, 6–11	2	260	0	0.14 (0.12 - 0.16)	0.076 (0.065 - 0.087)	0.13 (0.097 - 0.15)	0.20 (0.16 - 0.24)	0.33^{E} (0.13 - 0.53)
Males, 12–19	2	254	0	0.10 (0.094 - 0.12)	0.058 (0.052 - 0.063)	0.10 (0.093 - 0.12)	0.14 (0.12 - 0.16)	0.25 (0.19 - 0.31)
Males, 20–39	2	165	0	0.12 (0.098 - 0.15)	0.047 (0.034 - 0.060)	0.12 (0.083 - 0.15)	0.20^{E} (0.12 - 0.28)	x
Males, 40–59	2	193	0	0.16 (0.13 - 0.19)	0.074 (0.054 - 0.094)	0.15^{E} (0.095 - 0.21)	0.25 (0.19 - 0.30)	x
Males, 60–79	2	142	0	0.16 (0.13 - 0.19)	0.067 (0.052 - 0.083)	0.15 (0.12 - 0.17)	0.25 (0.20 - 0.29)	x
Females, Total 3–79	2	1248	0.08	0.17 (0.15 - 0.18)	0.078 (0.065 - 0.091)	0.15 (0.14 - 0.17)	0.24 (0.22 - 0.27)	0.56 (0.41 - 0.71)
Females, 6–11	2	248	0	0.15 (0.13 - 0.17)	0.082 (0.072 - 0.092)	0.13 (0.11 - 0.14)	0.19 (0.14 - 0.24)	0.55^{E} (0.27 - 0.83)
Females, 12–19	2	250	0	0.13 (0.12 - 0.15)	0.061 (0.047 - 0.075)	0.12 (0.099 - 0.15)	0.18 (0.12 - 0.24)	0.39 (0.28 - 0.51)
Females, 20–39	2	188	0	0.15 (0.13 - 0.18)	0.076 (0.058 - 0.094)	0.15 (0.11 - 0.20)	0.23 (0.19 - 0.28)	x
Females, 40–59	2	164	0	0.17 (0.14 - 0.20)	0.088 (0.067 - 0.11)	0.15 (0.12 - 0.18)	0.23 (0.18 - 0.28)	x
Females, 60–79	2	144	0.69	0.19 (0.17 - 0.22)	0.10 (0.085 - 0.12)	0.18 (0.13 - 0.22)	0.28 (0.22 - 0.33)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

16.7.2 2-Hydroxyphenanthrene

■ Table 16.7.2.1

2-Hydroxyphenanthrene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2520	0	0.067 (0.062 - 0.071)	0.027 (0.024 - 0.031)	0.065 (0.060 - 0.069)	0.099 (0.093 - 0.11)	0.23 (0.18 - 0.29)
3–5	2	506	0	0.043 (0.037 - 0.050)	0.023 (0.019 - 0.027)	0.040 (0.033 - 0.046)	0.057 (0.047 - 0.068)	0.11 (0.077 - 0.15)
6–11	2	510	0	0.052 (0.046 - 0.059)	0.025 (0.021 - 0.030)	0.050 (0.045 - 0.056)	0.073 (0.064 - 0.082)	0.14 (0.11 - 0.17)
12–19	2	506	0	0.067 (0.061 - 0.074)	0.033 (0.024 - 0.042)	0.064 (0.058 - 0.069)	0.098 (0.092 - 0.10)	0.19 (0.15 - 0.24)
20–39	2	354	0	0.069 (0.060 - 0.078)	0.028 (0.023 - 0.033)	0.067 (0.059 - 0.074)	0.10 (0.082 - 0.12)	0.23^{E} (0.13 - 0.32)
40–59	2	359	0	0.073 (0.064 - 0.083)	0.027 (0.018 - 0.036)	0.071 (0.062 - 0.081)	0.11 (0.093 - 0.13)	0.27 (0.20 - 0.35)
60–79	2	285	0	0.064 (0.057 - 0.071)	0.026 (0.018 - 0.034)	0.062 (0.055 - 0.070)	0.095 (0.084 - 0.10)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

■ Table 16.7.2.2

2-Hydroxyphenanthrene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1265	0	0.074 (0.066 - 0.083)	0.029 (0.025 - 0.033)	0.070 (0.062 - 0.078)	0.11 (0.086 - 0.12)	0.26 (0.19 - 0.33)
Males, 6–11	2	261	0	0.054 (0.045 - 0.064)	0.026 (0.022 - 0.029)	0.052 (0.042 - 0.061)	0.075 (0.057 - 0.093)	0.14 (0.092 - 0.19)
Males, 12–19	2	255	0	0.069 (0.063 - 0.075)	0.037 (0.029 - 0.045)	0.064 (0.056 - 0.072)	0.099 (0.091 - 0.11)	0.19^{E} (0.12 - 0.26)
Males, 20–39	2	165	0	0.079 (0.065 - 0.097)	0.030 (0.019 - 0.041)	0.087 (0.060 - 0.11)	0.12 (0.084 - 0.16)	x
Males, 40–59	2	193	0	0.084 (0.068 - 0.10)	0.027^{E} (0.015 - 0.039)	0.078 (0.060 - 0.096)	0.12^{E} (0.052 - 0.20)	x
Males, 60–79	2	140	0	0.068 (0.060 - 0.078)	0.033 (0.026 - 0.040)	0.065 (0.057 - 0.072)	0.091 (0.078 - 0.10)	x
Females, Total 3–79	2	1255	0	0.060 (0.056 - 0.065)	0.024 (0.020 - 0.029)	0.058 (0.052 - 0.064)	0.088 (0.078 - 0.098)	0.19^{E} (0.12 - 0.26)
Females, 6–11	2	249	0	0.051 (0.046 - 0.057)	0.024 (0.017 - 0.031)	0.049 (0.044 - 0.055)	0.072 (0.062 - 0.082)	0.13 (0.11 - 0.16)
Females, 12–19	2	251	0	0.065 (0.055 - 0.077)	0.029^{E} (0.017 - 0.041)	0.063 (0.051 - 0.074)	0.097 (0.084 - 0.11)	0.21 (0.17 - 0.25)
Females, 20–39	2	189	0	0.060 (0.052 - 0.069)	0.025 (0.021 - 0.029)	0.059 (0.050 - 0.068)	0.087 (0.067 - 0.11)	x
Females, 40–59	2	166	0	0.063 (0.052 - 0.078)	0.027^{E} (0.014 - 0.040)	0.065 (0.050 - 0.081)	0.093 (0.065 - 0.12)	x
Females, 60–79	2	145	0	0.060 (0.048 - 0.075)	0.017^{E} (0.0086 - 0.025)	0.053 (0.035 - 0.072)	0.096 (0.076 - 0.12)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.7.2.3

2-Hydroxyphenanthrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2510	0	0.067 (0.062 - 0.072)	0.031 (0.028 - 0.034)	0.063 (0.058 - 0.068)	0.093 (0.081 - 0.10)	0.19 (0.16 - 0.21)
3–5	2	505	0	0.076 (0.066 - 0.089)	0.040 (0.032 - 0.048)	0.076 (0.064 - 0.088)	0.10 (0.080 - 0.12)	0.18[E] (0.092 - 0.27)
6–11	2	508	0	0.061 (0.055 - 0.068)	0.035 (0.030 - 0.040)	0.057 (0.053 - 0.062)	0.078 (0.066 - 0.090)	0.18 (0.13 - 0.23)
12–19	2	504	0	0.051 (0.046 - 0.057)	0.028 (0.026 - 0.030)	0.048 (0.043 - 0.053)	0.066 (0.054 - 0.079)	0.13[E] (0.074 - 0.18)
20–39	2	352	0	0.061 (0.052 - 0.071)	0.030 (0.027 - 0.033)	0.058 (0.049 - 0.067)	0.086 (0.065 - 0.11)	0.19 (0.14 - 0.23)
40–59	2	357	0	0.074 (0.067 - 0.081)	0.034 (0.029 - 0.039)	0.071 (0.063 - 0.078)	0.11 (0.090 - 0.13)	0.19 (0.15 - 0.23)
60–79	2	284	0	0.075 (0.067 - 0.084)	0.037 (0.030 - 0.044)	0.067 (0.061 - 0.072)	0.098 (0.084 - 0.11)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 16.7.2.4

2-Hydroxyphenanthrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1261	0	0.064 (0.058 - 0.070)	0.030 (0.028 - 0.032)	0.059 (0.053 - 0.066)	0.088 (0.072 - 0.10)	0.19 (0.15 - 0.23)
Males, 6–11	2	260	0	0.061 (0.052 - 0.072)	0.036 (0.028 - 0.044)	0.057 (0.049 - 0.065)	0.076 (0.057 - 0.096)	0.18 (0.12 - 0.24)
Males, 12–19	2	254	0	0.049 (0.045 - 0.054)	0.029 (0.026 - 0.032)	0.047 (0.042 - 0.051)	0.059 (0.049 - 0.069)	0.11[E] (0.063 - 0.16)
Males, 20–39	2	164	0	0.060 (0.049 - 0.075)	0.029 (0.024 - 0.034)	0.052 (0.038 - 0.065)	0.080[E] (0.043 - 0.12)	x
Males, 40–59	2	193	0	0.072 (0.062 - 0.083)	0.030 (0.024 - 0.036)	0.071 (0.058 - 0.085)	0.11 (0.079 - 0.15)	x
Males, 60–79	2	140	0	0.064 (0.055 - 0.075)	0.032 (0.023 - 0.041)	0.061 (0.052 - 0.069)	0.085 (0.068 - 0.10)	x
Females, Total 3–79	2	1249	0	0.070 (0.062 - 0.078)	0.034 (0.028 - 0.040)	0.067 (0.061 - 0.073)	0.098 (0.084 - 0.11)	0.18 (0.12 - 0.24)
Females, 6–11	2	248	0	0.061 (0.055 - 0.068)	0.034 (0.028 - 0.039)	0.058 (0.052 - 0.063)	0.078 (0.068 - 0.089)	0.15[E] (0.086 - 0.21)
Females, 12–19	2	250	0	0.054 (0.046 - 0.064)	0.027 (0.024 - 0.030)	0.049 (0.039 - 0.060)	0.075 (0.054 - 0.096)	0.16 (0.11 - 0.22)
Females, 20–39	2	188	0	0.062 (0.050 - 0.076)	0.030 (0.024 - 0.037)	0.059 (0.049 - 0.070)	0.088 (0.060 - 0.12)	x
Females, 40–59	2	164	0	0.076 (0.064 - 0.090)	0.037 (0.028 - 0.047)	0.070 (0.060 - 0.081)	0.11 (0.082 - 0.13)	x
Females, 60–79	2	144	0	0.086 (0.071 - 0.11)	0.040 (0.032 - 0.047)	0.074 (0.062 - 0.086)	0.12 (0.095 - 0.14)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

16.7.3 3-Hydroxyphenanthrene

Table 16.7.3.1

3-Hydroxyphenanthrene — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2515	0	0.087 (0.080 - 0.095)	0.026 (0.023 - 0.029)	0.089 (0.080 - 0.098)	0.15 (0.13 - 0.17)	0.39 (0.31 - 0.46)
3–5	2	501	0	0.077 (0.068 - 0.086)	0.030 (0.026 - 0.034)	0.076 (0.064 - 0.088)	0.12 (0.097 - 0.15)	0.28 (0.20 - 0.35)
6–11	2	509	0	0.084 (0.070 - 0.10)	0.029 (0.023 - 0.035)	0.092 (0.072 - 0.11)	0.13 (0.099 - 0.17)	0.28 (0.21 - 0.34)
12–19	2	506	0	0.094 (0.083 - 0.11)	0.033 (0.025 - 0.042)	0.091 (0.077 - 0.10)	0.15 (0.13 - 0.17)	0.35^{E} (0.20 - 0.50)
20–39	2	355	0	0.091 (0.078 - 0.11)	0.027 (0.020 - 0.034)	0.099 (0.070 - 0.13)	0.17 (0.14 - 0.19)	0.38 (0.27 - 0.49)
40–59	2	358	0	0.091 (0.078 - 0.11)	0.023^{E} (0.014 - 0.032)	0.093 (0.082 - 0.10)	0.17 (0.13 - 0.21)	0.44^{E} (0.27 - 0.60)
60–79	2	286	0	0.073 (0.063 - 0.085)	0.020 (0.016 - 0.025)	0.073 (0.059 - 0.086)	0.13 (0.096 - 0.16)	0.33^{E} (0.12 - 0.54)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.7.3.2

3-Hydroxyphenanthrene — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1265	0	0.10 (0.087 - 0.12)	0.030 (0.026 - 0.035)	0.099 (0.085 - 0.11)	0.17 (0.14 - 0.21)	0.45 (0.30 - 0.60)
Males, 6–11	2	261	0	0.086 (0.068 - 0.11)	0.031 (0.026 - 0.036)	0.097 (0.065 - 0.13)	0.14^{E} (0.069 - 0.22)	0.27 (0.20 - 0.35)
Males, 12–19	2	255	0	0.10 (0.088 - 0.12)	0.040 (0.029 - 0.052)	0.092 (0.075 - 0.11)	0.16 (0.13 - 0.19)	F
Males, 20–39	2	166	0	0.11 (0.087 - 0.14)	0.033^{E} (0.021 - 0.045)	0.12 (0.080 - 0.17)	0.18^{E} (0.11 - 0.25)	x
Males, 40–59	2	193	0	0.11 (0.082 - 0.14)	0.027^{E} (0.017 - 0.036)	0.099^{E} (0.060 - 0.14)	0.19^{E} (0.092 - 0.29)	x
Males, 60–79	2	142	0	0.085 (0.068 - 0.11)	0.028 (0.021 - 0.035)	0.087 (0.069 - 0.10)	0.13 (0.10 - 0.17)	x
Females, Total 3–79	2	1250	0	0.075 (0.069 - 0.082)	0.022 (0.018 - 0.026)	0.078 (0.066 - 0.090)	0.13 (0.11 - 0.15)	0.35 (0.26 - 0.44)
Females, 6–11	2	248	0	0.081 (0.070 - 0.095)	0.027 (0.018 - 0.035)	0.091 (0.075 - 0.11)	0.13 (0.11 - 0.15)	0.31 (0.21 - 0.40)
Females, 12–19	2	251	0	0.087 (0.073 - 0.10)	0.028^{E} (0.015 - 0.041)	0.091 (0.075 - 0.11)	0.15 (0.12 - 0.17)	0.31^{E} (0.17 - 0.45)
Females, 20–39	2	189	0	0.077 (0.064 - 0.093)	0.026^{E} (0.013 - 0.039)	0.081 (0.056 - 0.11)	0.14 (0.12 - 0.17)	x
Females, 40–59	2	165	0	0.076 (0.059 - 0.098)	0.022^{E} (0.011 - 0.033)	0.079 (0.055 - 0.10)	0.11 (0.077 - 0.15)	x
Females, 60–79	2	144	0	0.064 (0.051 - 0.080)	0.016 (0.010 - 0.022)	0.061 (0.042 - 0.080)	0.11^{E} (0.069 - 0.16)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.7.3.3

3-Hydroxyphenanthrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2505	0	0.087 (0.080 - 0.094)	0.038 (0.035 - 0.042)	0.079 (0.073 - 0.086)	0.12 (0.11 - 0.14)	0.38 (0.29 - 0.47)
3–5	2	500	0	0.14 (0.12 - 0.15)	0.068 (0.059 - 0.076)	0.13 (0.11 - 0.15)	0.19 (0.14 - 0.23)	0.36 (0.28 - 0.44)
6–11	2	507	0	0.098 (0.086 - 0.11)	0.049 (0.039 - 0.059)	0.088 (0.075 - 0.10)	0.14 (0.12 - 0.16)	0.27^{E} (0.10 - 0.44)
12–19	2	504	0	0.072 (0.064 - 0.081)	0.037 (0.034 - 0.040)	0.068 (0.062 - 0.074)	0.095 (0.079 - 0.11)	0.23^{E} (0.13 - 0.32)
20–39	2	353	0	0.081 (0.071 - 0.093)	0.038 (0.033 - 0.043)	0.069 (0.055 - 0.082)	0.12 (0.11 - 0.14)	0.38^{E} (0.23 - 0.52)
40–59	2	356	0	0.092 (0.083 - 0.10)	0.037 (0.032 - 0.043)	0.086 (0.073 - 0.10)	0.13 (0.10 - 0.16)	0.46 (0.32 - 0.59)
60–79	2	285	0	0.085 (0.075 - 0.097)	0.039 (0.032 - 0.046)	0.078 (0.071 - 0.084)	0.13 (0.11 - 0.15)	0.30^{E} (0.12 - 0.47)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.7.3.4

3-Hydroxyphenanthrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1261	0	0.086 (0.076 - 0.098)	0.035 (0.031 - 0.039)	0.080 (0.069 - 0.090)	0.13 (0.11 - 0.15)	0.42 (0.29 - 0.56)
Males, 6–11	2	260	0	0.098 (0.080 - 0.12)	0.047 (0.034 - 0.060)	0.088 (0.061 - 0.12)	0.14 (0.11 - 0.17)	0.26^{E} (0.12 - 0.41)
Males, 12–19	2	254	0	0.072 (0.063 - 0.082)	0.037 (0.033 - 0.040)	0.070 (0.061 - 0.079)	0.094 (0.078 - 0.11)	0.22^{E} (0.080 - 0.37)
Males, 20–39	2	165	0	0.083 (0.064 - 0.11)	0.031 (0.022 - 0.041)	0.066^{E} (0.041 - 0.091)	0.14 (0.092 - 0.18)	x
Males, 40–59	2	193	0	0.093 (0.077 - 0.11)	0.032 (0.021 - 0.044)	0.084 (0.064 - 0.10)	0.15^{E} (0.078 - 0.23)	x
Males, 60–79	2	142	0	0.079 (0.065 - 0.097)	0.035^{E} (0.019 - 0.052)	0.074 (0.063 - 0.084)	0.12 (0.092 - 0.14)	x
Females, Total 3–79	2	1244	0	0.087 (0.079 - 0.095)	0.042 (0.037 - 0.047)	0.079 (0.072 - 0.086)	0.12 (0.11 - 0.13)	0.31^{E} (0.15 - 0.47)
Females, 6–11	2	247	0	0.098 (0.089 - 0.11)	0.055 (0.047 - 0.062)	0.088 (0.079 - 0.097)	0.13 (0.11 - 0.16)	F
Females, 12–19	2	250	0	0.072 (0.062 - 0.084)	0.037 (0.030 - 0.044)	0.065 (0.056 - 0.075)	0.095 (0.073 - 0.12)	0.24^{E} (0.15 - 0.33)
Females, 20–39	2	188	0	0.080 (0.072 - 0.089)	0.044 (0.037 - 0.050)	0.075 (0.061 - 0.089)	0.11 (0.091 - 0.13)	x
Females, 40–59	2	163	0	0.091 (0.075 - 0.11)	0.040 (0.031 - 0.050)	0.088 (0.069 - 0.11)	0.12 (0.094 - 0.16)	x
Females, 60–79	2	143	0	0.091 (0.079 - 0.10)	0.044 (0.036 - 0.051)	0.079 (0.072 - 0.086)	0.15 (0.11 - 0.18)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

16.7.4 4-Hydroxyphenanthrene

Table 16.7.4.1

4-Hydroxyphenanthrene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2519	0.08	0.025 (0.022 - 0.027)	0.0070 (0.0059 - 0.0081)	0.023 (0.020 - 0.026)	0.047 (0.039 - 0.054)	0.13 (0.11 - 0.15)
3–5	2	505	0	0.017 (0.015 - 0.020)	0.0060 (0.0047 - 0.0072)	0.017 (0.014 - 0.020)	0.028 (0.023 - 0.034)	0.063^{E} (0.032 - 0.093)
6–11	2	510	0	0.019 (0.016 - 0.023)	0.0067 (0.0057 - 0.0077)	0.019 (0.014 - 0.023)	0.030 (0.023 - 0.037)	0.074 (0.049 - 0.099)
12–19	2	505	0.20	0.023 (0.020 - 0.025)	0.0079 (0.0057 - 0.010)	0.022 (0.020 - 0.025)	0.037 (0.030 - 0.044)	0.094 (0.062 - 0.12)
20–39	2	355	0	0.026 (0.022 - 0.031)	0.0070 (0.0050 - 0.0090)	0.027 (0.019 - 0.035)	0.054 (0.043 - 0.065)	0.13 (0.086 - 0.18)
40–59	2	357	0	0.027 (0.023 - 0.032)	0.0082 (0.0056 - 0.011)	0.024 (0.018 - 0.029)	0.050 (0.036 - 0.063)	0.15^{E} (0.097 - 0.21)
60–79	2	287	0.35	0.023 (0.020 - 0.027)	0.0060 (0.0047 - 0.0074)	0.021 (0.017 - 0.026)	0.043 (0.037 - 0.049)	0.14^{E} (0.075 - 0.21)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.7.4.2

4-Hydroxyphenanthrene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1266	0	0.027 (0.023 - 0.032)	0.0075 (0.0057 - 0.0094)	0.026 (0.020 - 0.031)	0.051 (0.039 - 0.062)	0.15 (0.10 - 0.20)
Males, 6–11	2	261	0	0.020 (0.016 - 0.025)	0.0068 (0.0054 - 0.0082)	0.020 (0.013 - 0.026)	0.032 (0.023 - 0.042)	0.074 (0.056 - 0.092)
Males, 12–19	2	254	0	0.023 (0.019 - 0.026)	0.0092 (0.0068 - 0.012)	0.022 (0.018 - 0.026)	0.037 (0.028 - 0.045)	0.073^{E} (0.032 - 0.11)
Males, 20–39	2	166	0	0.029 (0.022 - 0.039)	0.0067^{E} (0.0028 - 0.011)	0.034 (0.022 - 0.047)	0.054 (0.035 - 0.073)	x
Males, 40–59	2	192	0	0.031 (0.024 - 0.041)	0.0088^{E} (0.0055 - 0.012)	0.026^{E} (0.015 - 0.037)	0.073^{E} (0.034 - 0.11)	x
Males, 60–79	2	142	0	0.025 (0.020 - 0.031)	0.0080 (0.0061 - 0.010)	0.021^{E} (0.011 - 0.030)	0.046 (0.032 - 0.059)	x
Females, Total 3–79	2	1253	0.16	0.023 (0.021 - 0.025)	0.0061 (0.0049 - 0.0073)	0.022 (0.019 - 0.024)	0.043 (0.037 - 0.048)	0.13 (0.095 - 0.16)
Females, 6–11	2	249	0	0.019 (0.015 - 0.022)	0.0063 (0.0050 - 0.0076)	0.018 (0.013 - 0.022)	0.029 (0.022 - 0.036)	0.10^{E} (0.056 - 0.15)
Females, 12–19	2	251	0.40	0.023 (0.019 - 0.028)	0.0071^{E} (0.0043 - 0.0098)	0.023 (0.020 - 0.027)	0.039 (0.028 - 0.051)	0.11^{E} (0.059 - 0.15)
Females, 20–39	2	189	0	0.024 (0.020 - 0.028)	0.0064^{E} (0.0033 - 0.0095)	0.022 (0.016 - 0.027)	0.047 (0.031 - 0.063)	x
Females, 40–59	2	165	0	0.024 (0.018 - 0.031)	0.0079^{E} (0.0045 - 0.011)	0.023 (0.017 - 0.028)	0.041 (0.028 - 0.054)	x
Females, 60–79	2	145	0.69	0.021 (0.016 - 0.027)	0.0045^{E} (0.0026 - 0.0063)	0.022^{E} (0.013 - 0.030)	0.043 (0.031 - 0.054)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.7.4.3

4-Hydroxyphenanthrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2509	0.08	0.025 (0.022 - 0.027)	0.0095 (0.0085 - 0.010)	0.023 (0.020 - 0.026)	0.040 (0.035 - 0.044)	0.12 (0.085 - 0.15)
3–5	2	504	0	0.031 (0.027 - 0.035)	0.012 (0.0085 - 0.015)	0.028 (0.024 - 0.032)	0.050 (0.039 - 0.060)	0.10 (0.077 - 0.13)
6–11	2	508	0	0.023 (0.019 - 0.026)	0.011 (0.0088 - 0.012)	0.019 (0.016 - 0.023)	0.034 (0.027 - 0.040)	0.080 (0.061 - 0.10)
12–19	2	503	0.20	0.017 (0.016 - 0.020)	0.0081 (0.0073 - 0.0089)	0.016 (0.014 - 0.017)	0.024 (0.019 - 0.029)	0.059 (0.040 - 0.079)
20–39	2	353	0	0.023 (0.019 - 0.028)	0.0082 (0.0067 - 0.0098)	0.021 (0.016 - 0.025)	0.038 (0.030 - 0.046)	0.12^{E} (0.063 - 0.17)
40–59	2	355	0	0.027 (0.024 - 0.031)	0.0098 (0.0083 - 0.011)	0.025 (0.020 - 0.031)	0.044 (0.034 - 0.053)	0.14 (0.094 - 0.19)
60–79	2	286	0.35	0.027 (0.023 - 0.031)	0.0095 (0.0075 - 0.012)	0.027 (0.022 - 0.032)	0.042 (0.037 - 0.047)	0.14^{E} (0.075 - 0.20)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.7.4.4

4-Hydroxyphenanthrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1262	0	0.023 (0.020 - 0.027)	0.0082 (0.0073 - 0.0092)	0.020 (0.016 - 0.024)	0.039 (0.031 - 0.047)	0.14 (0.088 - 0.18)
Males, 6–11	2	260	0	0.023 (0.019 - 0.028)	0.011 (0.0091 - 0.013)	0.020 (0.014 - 0.027)	0.034 (0.024 - 0.043)	0.078 (0.059 - 0.098)
Males, 12–19	2	253	0	0.016 (0.014 - 0.018)	0.0080 (0.0070 - 0.0089)	0.015 (0.012 - 0.017)	0.022 (0.017 - 0.026)	0.047 (0.034 - 0.060)
Males, 20–39	2	165	0	0.022 (0.016 - 0.029)	0.0076 (0.0065 - 0.0088)	0.018 (0.013 - 0.024)	0.034^{E} (0.017 - 0.050)	x
Males, 40–59	2	192	0	0.027 (0.021 - 0.033)	0.0093 (0.0061 - 0.013)	0.023^{E} (0.012 - 0.033)	0.046^{E} (0.020 - 0.071)	x
Males, 60–79	2	142	0	0.024 (0.019 - 0.030)	0.0088 (0.0065 - 0.011)	0.022 (0.015 - 0.029)	0.034 (0.026 - 0.042)	x
Females, Total 3–79	2	1247	0.16	0.026 (0.023 - 0.029)	0.010 (0.0090 - 0.012)	0.025 (0.021 - 0.030)	0.040 (0.035 - 0.045)	0.11 (0.075 - 0.14)
Females, 6–11	2	248	0	0.022 (0.019 - 0.026)	0.0095 (0.0074 - 0.012)	0.019 (0.016 - 0.022)	0.033 (0.024 - 0.041)	0.096 (0.062 - 0.13)
Females, 12–19	2	250	0.40	0.019 (0.016 - 0.023)	0.0082 (0.0060 - 0.010)	0.017 (0.015 - 0.019)	0.027^{E} (0.016 - 0.039)	0.082^{E} (0.050 - 0.11)
Females, 20–39	2	188	0	0.025 (0.021 - 0.030)	0.010 (0.0080 - 0.012)	0.023 (0.015 - 0.031)	0.039 (0.033 - 0.046)	x
Females, 40–59	2	163	0	0.028 (0.023 - 0.034)	0.0099^{E} (0.0063 - 0.014)	0.028 (0.021 - 0.034)	0.036 (0.024 - 0.048)	x
Females, 60–79	2	144	0.69	0.030 (0.025 - 0.036)	0.013 (0.0092 - 0.018)	0.030 (0.025 - 0.035)	0.044 (0.038 - 0.050)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

16.7.5 9-Hydroxyphenanthrene

Table 16.7.5.1

9-Hydroxyphenanthrene — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2474	5.86	0.039 (0.034 - 0.044)	0.0075 (0.0066 - 0.0084)	0.036 (0.029 - 0.043)	0.075 (0.058 - 0.092)	0.41 (0.33 - 0.49)
3–5	2	490	11.43	0.018 (0.015 - 0.022)	<LOD	0.020 (0.017 - 0.023)	0.036 (0.026 - 0.046)	0.095^{E} (0.041 - 0.15)
6–11	2	502	5.78	0.019 (0.015 - 0.023)	0.0044^{E} (<LOD - 0.0075)	0.022 (0.017 - 0.026)	0.035 (0.030 - 0.040)	0.076 (0.055 - 0.097)
12–19	2	499	5.41	0.027 (0.023 - 0.032)	0.0073 (0.0058 - 0.0089)	0.029 (0.023 - 0.035)	0.052 (0.043 - 0.061)	0.15^{E} (0.092 - 0.20)
20–39	2	348	3.45	0.041 (0.034 - 0.050)	0.0088^{E} (0.0055 - 0.012)	0.040 (0.030 - 0.050)	0.071 (0.054 - 0.089)	0.39^{E} (0.20 - 0.58)
40–59	2	350	3.14	0.049 (0.040 - 0.059)	0.0089 (0.0071 - 0.011)	0.045 (0.034 - 0.056)	0.11^{E} (0.061 - 0.17)	0.48 (0.40 - 0.56)
60–79	2	285	3.51	0.043 (0.033 - 0.057)	0.0065^{E} (<LOD - 0.0092)	0.035 (0.024 - 0.045)	0.12^{E} (0.071 - 0.16)	0.60^{E} (0.34 - 0.85)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.7.5.2

9-Hydroxyphenanthrene — Geometric means and selected percentiles of urine concentrations (μg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1249	5.44	0.043 (0.035 - 0.052)	0.0080 (0.0065 - 0.0094)	0.043 (0.033 - 0.053)	0.086^{E} (0.043 - 0.13)	0.49 (0.32 - 0.65)
Males, 6–11	2	257	6.23	0.018 (0.013 - 0.025)	F	0.022 (0.015 - 0.028)	0.034 (0.027 - 0.042)	0.059 (0.041 - 0.078)
Males, 12–19	2	254	3.94	0.027 (0.022 - 0.033)	0.0080 (0.0067 - 0.0094)	0.026 (0.018 - 0.035)	0.050 (0.036 - 0.063)	0.12 (0.083 - 0.17)
Males, 20–39	2	165	3.03	0.041 (0.030 - 0.055)	F	0.049 (0.035 - 0.064)	0.074^{E} (0.033 - 0.11)	x
Males, 40–59	2	189	2.65	0.061 (0.045 - 0.083)	0.0091^{E} (<LOD - 0.015)	0.057^{E} (0.033 - 0.081)	0.15^{E} (0.087 - 0.22)	x
Males, 60–79	2	141	1.42	0.054^{E} (0.037 - 0.079)	0.0097^{E} (<LOD - 0.016)	0.039^{E} (0.019 - 0.058)	F	x
Females, Total 3–79	2	1225	6.29	0.035 (0.030 - 0.040)	0.0070 (0.0053 - 0.0086)	0.032 (0.028 - 0.036)	0.067 (0.053 - 0.082)	0.38 (0.26 - 0.50)
Females, 6–11	2	245	5.31	0.019 (0.015 - 0.025)	F	0.021 (0.015 - 0.028)	0.037 (0.028 - 0.046)	F
Females, 12–19	2	245	6.94	0.028 (0.022 - 0.036)	F	0.031 (0.023 - 0.039)	0.057 (0.041 - 0.072)	0.20^{E} (0.058 - 0.34)
Females, 20–39	2	183	3.83	0.042 (0.032 - 0.054)	0.0095 (0.0061 - 0.013)	0.032 (0.026 - 0.039)	0.069^{E} (0.029 - 0.11)	x
Females, 40–59	2	161	3.73	0.039 (0.028 - 0.054)	0.0083 (0.0064 - 0.010)	0.036 (0.025 - 0.046)	F	x
Females, 60–79	2	144	5.56	0.035^{E} (0.023 - 0.052)	0.0048^{E} (<LOD - 0.0078)	0.031 (0.024 - 0.039)	0.11^{E} (0.064 - 0.15)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.7.5.3

9-Hydroxyphenanthrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2464	5.88	0.039 (0.034 - 0.045)	0.011 (0.0096 - 0.013)	0.033 (0.027 - 0.038)	0.075 (0.051 - 0.099)	0.34 (0.27 - 0.42)
3–5	2	489	11.45	0.032 (0.028 - 0.038)	<LOD	0.037 (0.031 - 0.043)	0.059 (0.044 - 0.073)	0.14^{E} (0.090 - 0.20)
6–11	2	500	5.80	0.023 (0.019 - 0.027)	0.0074^{E} (<LOD - 0.011)	0.025 (0.022 - 0.029)	0.038 (0.031 - 0.044)	0.071 (0.050 - 0.093)
12–19	2	497	5.43	0.021 (0.018 - 0.024)	0.0080 (0.0067 - 0.0094)	0.020 (0.017 - 0.023)	0.033 (0.027 - 0.040)	0.088^{E} (0.042 - 0.13)
20–39	2	346	3.47	0.037 (0.029 - 0.047)	0.012^{E} (0.0063 - 0.017)	0.028 (0.021 - 0.035)	0.065^{E} (0.029 - 0.10)	0.36^{E} (0.22 - 0.50)
40–59	2	348	3.16	0.049 (0.040 - 0.061)	0.013 (0.0088 - 0.017)	0.043 (0.030 - 0.056)	0.098^{E} (0.044 - 0.15)	0.41 (0.26 - 0.55)
60–79	2	284	3.52	0.051 (0.040 - 0.065)	0.015 (<LOD - 0.019)	0.038^{E} (0.020 - 0.056)	0.12 (0.078 - 0.15)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 16.7.5.4

9-Hydroxyphenanthrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1245	5.46	0.037 (0.030 - 0.045)	0.0098 (0.0070 - 0.013)	0.029 (0.022 - 0.036)	0.072^{E} (0.039 - 0.11)	0.38 (0.27 - 0.48)
Males, 6–11	2	256	6.25	0.021 (0.016 - 0.028)	F	0.025 (0.019 - 0.030)	0.038 (0.030 - 0.046)	0.057 (0.043 - 0.070)
Males, 12–19	2	253	3.95	0.019 (0.016 - 0.024)	0.0079 (0.0062 - 0.0095)	0.020 (0.016 - 0.023)	0.031 (0.023 - 0.040)	0.070^{E} (0.044 - 0.095)
Males, 20–39	2	164	3.05	0.031 (0.021 - 0.044)	F	0.024 (0.018 - 0.031)	F	x
Males, 40–59	2	189	2.65	0.053 (0.039 - 0.073)	0.012^{E} (<LOD - 0.019)	0.046^{E} (0.024 - 0.069)	0.12^{E} (0.053 - 0.20)	x
Males, 60–79	2	141	1.42	0.051 (0.036 - 0.071)	0.013 (<LOD - 0.017)	0.037^{E} (0.020 - 0.053)	0.13^{E} (0.059 - 0.21)	x
Females, Total 3–79	2	1219	6.32	0.041 (0.035 - 0.048)	0.013 (0.010 - 0.016)	0.035 (0.028 - 0.043)	0.081 (0.056 - 0.11)	0.29^{E} (0.18 - 0.40)
Females, 6–11	2	244	5.33	0.024 (0.019 - 0.030)	0.0074^{E} (<LOD - 0.013)	0.027 (0.023 - 0.031)	0.037 (0.030 - 0.045)	0.094^{E} (<LOD - 0.16)
Females, 12–19	2	244	6.97	0.023 (0.018 - 0.029)	0.0084^{E} (<LOD - 0.013)	0.024 (0.019 - 0.029)	0.034 (0.022 - 0.046)	0.12^{E} (0.038 - 0.21)
Females, 20–39	2	182	3.85	0.044 (0.032 - 0.060)	0.016 (0.011 - 0.021)	0.034^{E} (0.020 - 0.048)	F	x
Females, 40–59	2	159	3.77	0.046 (0.034 - 0.062)	0.015^{E} (0.0087 - 0.021)	0.042 (0.027 - 0.056)	0.096^{E} (<LOD - 0.14)	x
Females, 60–79	2	143	5.59	0.051 (0.038 - 0.069)	0.017^{E} (<LOD - 0.023)	0.046^{E} (0.024 - 0.069)	0.10 (0.069 - 0.14)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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16.8 PYRENE METABOLITE

Pyrene is a polycyclic aromatic hydrocarbon (PAH) with four fused benzene rings. Pyrene is used as an intermediate in the synthesis of dyes and fluorescent molecular probes for biomedical research (WHO, 1998).

Pyrene absorption occurs rapidly in the respiratory tract, but more slowly through the gastrointestinal tract and skin (Faust, 1993). After oral administration in rats, pyrene has been found predominantly in the gastrointestinal tract (Mitchell & Tu, 1979). 1-Hydroxypyrene has been identified as the primary metabolite of pyrene (IARC, 2010). In humans, urinary elimination of 1-hydroxypyrene is triphasic with half-lives of 5, 22, and 408 hours (ACGIH, 2005). Monitoring studies of pyrene exposure can measure urinary levels of 1-hydroxypyrene to assess recent and chronic exposures (Becker et al., 2003; CDC, 2009; Hopf et al., 2009; Jongeneelen et al., 1985). Urinary 1-hydroxypyrene may also serve as a useful biomarker for total PAH exposure, given that pyrene is found in most PAH mixtures (Hopf et al., 2009; WHO, 1998).

Subchronic oral exposure to pyrene results in kidney and liver effects in laboratory animals and the liver has been suggested as the main target organ for toxicity (Faust, 1993; TRL, 1989). Pyrene has not been found to be carcinogenic in animals, and the International Agency for Research on Cancer has classified pyrene as Group 3, not classifiable as to its carcinogenicity to humans (IARC, 2010).

1-Hydroxypyrene was measured in the urine of 73 non-smoking, non-occupationally exposed residents (aged 16 to 64 years) living approximately 1 km from an aluminum plant in Baie-Comeau, Quebec. The geometric mean levels ranged from 0.090 to 0.111 µg/g creatinine, compared with 0.048 to 0.077 µg/g creatinine for 71 control individuals living at least 11 km from the plant (Bouchard et al., 2009). Firefighters from Toronto, Ontario, were assessed for their exposure to PAHs from firefighting operations while wearing protective equipment (Caux et al., 2002). Urine was collected from 43 individuals for 20 hours after exposure, and urinary 1-hydroxypyrene levels ranged from <0.043 to 7.00 µg/g creatinine (Caux et al., 2002).

1-Hydroxypyrene was measured in the urine of all Canadian Health Measures Survey cycle 2 (2009–2011) participants aged 3 to 79 years and is presented as both µg/L and µg/g creatinine (Tables 16.8.1.1, 16.8.1.2, 16.8.1.3, and 16.8.1.4). Finding a measurable amount of 1-hydroxypyrene in urine is an indicator of exposure to pyrene and does not necessarily mean that an adverse health effect will occur. These data provide baseline levels for urinary 1-hydroxypyrene in the Canadian population.

16.8.1 1-Hydroxypyrene

Table 16.8.1.1

1-Hydroxypyrene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD^{a}	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2422	0.04	0.11 (0.099 - 0.12)	0.031 (0.027 - 0.034)	0.10 (0.092 - 0.11)	0.19 (0.17 - 0.22)	0.57 (0.47 - 0.68)
3–5	2	504	0	0.12 (0.11 - 0.13)	0.050 (0.041 - 0.059)	0.11 (0.10 - 0.12)	0.19 (0.16 - 0.23)	0.40 (0.30 - 0.51)
6–11	2	507	0	0.13 (0.11 - 0.15)	0.049 (0.039 - 0.058)	0.12 (0.096 - 0.14)	0.20 (0.15 - 0.25)	0.47 (0.34 - 0.60)
12–19	2	480	0	0.15 (0.14 - 0.17)	0.050^{E} (0.031 - 0.069)	0.15 (0.13 - 0.17)	0.25 (0.21 - 0.28)	0.62 (0.45 - 0.79)
20–39	2	327	0	0.13 (0.11 - 0.15)	0.041 (0.027 - 0.054)	0.12 (0.10 - 0.14)	0.23 (0.19 - 0.28)	0.48^{E} (0.27 - 0.69)
40–59	2	329	0.30	0.10 (0.084 - 0.12)	0.026^{E} (0.012 - 0.039)	0.094 (0.076 - 0.11)	0.17^{E} (0.080 - 0.26)	0.58 (0.47 - 0.69)
60–79	2	275	0	0.067 (0.057 - 0.079)	0.024 (0.018 - 0.030)	0.062 (0.048 - 0.076)	0.11 (0.078 - 0.15)	F

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

F Data is too unreliable to be published.

Table 16.8.1.2

1-Hydroxypyrene — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1206	0	0.12 (0.11 - 0.14)	0.040 (0.034 - 0.045)	0.12 (0.10 - 0.13)	0.21 (0.17 - 0.25)	0.59 (0.46 - 0.73)
Males, 6–11	2	259	0	0.12 (0.10 - 0.15)	0.055 (0.043 - 0.068)	0.12 (0.090 - 0.15)	0.19 (0.14 - 0.25)	0.35 (0.24 - 0.47)
Males, 12–19	2	243	0	0.15 (0.13 - 0.17)	0.054[E] (0.033 - 0.075)	0.13 (0.11 - 0.16)	0.24 (0.21 - 0.28)	0.60 (0.40 - 0.81)
Males, 20–39	2	149	0	0.14 (0.11 - 0.18)	0.042[E] (0.023 - 0.061)	0.14 (0.094 - 0.19)	0.25 (0.20 - 0.30)	x
Males, 40–59	2	173	0	0.12 (0.092 - 0.17)	0.034[E] (0.012 - 0.056)	0.11 (0.082 - 0.15)	0.23[E] (0.12 - 0.35)	x
Males, 60–79	2	133	0	0.079 (0.061 - 0.10)	0.025[E] (0.013 - 0.038)	0.078 (0.060 - 0.097)	0.14 (0.10 - 0.18)	x
Females, Total 3–79	2	1216	0.08	0.095 (0.088 - 0.10)	0.026 (0.021 - 0.031)	0.095 (0.085 - 0.10)	0.17 (0.15 - 0.19)	0.48 (0.34 - 0.62)
Females, 6–11	2	248	0	0.13 (0.11 - 0.15)	0.048 (0.034 - 0.062)	0.11 (0.089 - 0.13)	0.22 (0.15 - 0.29)	0.55[E] (0.29 - 0.81)
Females, 12–19	2	237	0	0.16 (0.13 - 0.18)	0.042[E] (0.017 - 0.067)	0.17 (0.14 - 0.20)	0.25 (0.20 - 0.30)	0.65[E] (0.42 - 0.89)
Females, 20–39	2	178	0	0.11 (0.096 - 0.14)	0.039[E] (0.018 - 0.061)	0.11 (0.093 - 0.14)	0.22 (0.15 - 0.28)	x
Females, 40–59	2	156	0.64	0.083 (0.063 - 0.11)	0.022[E] (0.0091 - 0.034)	0.071[E] (0.045 - 0.096)	0.16[E] (0.094 - 0.22)	x
Females, 60–79	2	142	0	0.058 (0.047 - 0.072)	0.017[E] (0.0090 - 0.025)	0.052 (0.039 - 0.064)	0.089 (0.061 - 0.12)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 16.8.1.3

1-Hydroxypyrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total, 3–79	2	2412	0.04	0.11 (0.10 - 0.12)	0.046 (0.043 - 0.049)	0.10 (0.094 - 0.11)	0.16 (0.14 - 0.19)	0.41 (0.31 - 0.50)
3–5	2	503	0	0.21 (0.20 - 0.23)	0.11 (0.092 - 0.13)	0.21 (0.18 - 0.23)	0.30 (0.27 - 0.33)	0.52 (0.43 - 0.61)
6–11	2	505	0	0.15 (0.13 - 0.16)	0.074 (0.062 - 0.086)	0.14 (0.13 - 0.16)	0.21 (0.18 - 0.25)	0.37 (0.26 - 0.49)
12–19	2	478	0	0.12 (0.10 - 0.13)	0.056 (0.051 - 0.062)	0.11 (0.096 - 0.12)	0.16 (0.13 - 0.19)	0.39[E] (0.21 - 0.56)
20–39	2	325	0	0.12 (0.096 - 0.14)	0.051 (0.035 - 0.066)	0.10 (0.087 - 0.12)	0.16 (0.12 - 0.21)	0.41 (0.27 - 0.55)
40–59	2	327	0.31	0.10 (0.090 - 0.12)	0.044 (0.039 - 0.048)	0.094 (0.084 - 0.10)	0.17 (0.12 - 0.22)	0.59[E] (0.24 - 0.94)
60–79	2	274	0	0.079 (0.069 - 0.092)	0.035 (0.029 - 0.042)	0.079 (0.073 - 0.085)	0.12 (0.091 - 0.14)	0.23[E] (<LOD - 0.36)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 16.8.1.4

1-Hydroxypyrene (creatinine adjusted) — Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Males, Total 3–79	2	1202	0	0.11 (0.093 - 0.12)	0.042 (0.036 - 0.048)	0.098 (0.089 - 0.11)	0.17 (0.14 - 0.20)	0.45[E] (0.29 - 0.62)
Males, 6–11	2	258	0	0.14 (0.12 - 0.17)	0.078 (0.065 - 0.090)	0.13 (0.10 - 0.16)	0.21 (0.17 - 0.26)	0.32 (0.24 - 0.40)
Males, 12–19	2	242	0	0.11 (0.098 - 0.12)	0.051 (0.042 - 0.061)	0.094 (0.081 - 0.11)	0.15 (0.13 - 0.17)	0.43[E] (0.18 - 0.68)
Males, 20–39	2	148	0	0.11 (0.080 - 0.16)	0.049[E] (0.030 - 0.067)	0.097 (0.071 - 0.12)	0.18[E] (0.085 - 0.27)	x
Males, 40–59	2	173	0	0.11 (0.081 - 0.14)	0.041 (0.031 - 0.052)	0.098 (0.068 - 0.13)	0.17 (0.12 - 0.23)	x
Males, 60–79	2	133	0	0.074 (0.058 - 0.095)	0.033[E] (0.019 - 0.046)	0.074 (0.058 - 0.089)	0.11 (0.080 - 0.13)	x
Females, Total 3–79	2	1210	0.08	0.11 (0.10 - 0.12)	0.049 (0.045 - 0.052)	0.10 (0.093 - 0.11)	0.16 (0.14 - 0.18)	0.39 (0.28 - 0.49)
Females, 6–11	2	247	0	0.15 (0.14 - 0.17)	0.069 (0.054 - 0.085)	0.15 (0.13 - 0.16)	0.21 (0.17 - 0.24)	0.49[E] (0.24 - 0.74)
Females, 12–19	2	236	0	0.13 (0.11 - 0.15)	0.061 (0.046 - 0.075)	0.12 (0.099 - 0.14)	0.16[E] (0.10 - 0.22)	0.38[E] (0.24 - 0.52)
Females, 20–39	2	177	0	0.12 (0.10 - 0.14)	0.066 (0.049 - 0.084)	0.12 (0.10 - 0.14)	0.15 (0.10 - 0.20)	x
Females, 40–59	2	154	0.65	0.10 (0.085 - 0.13)	0.046 (0.038 - 0.055)	0.090 (0.083 - 0.097)	0.14[E] (0.067 - 0.21)	x
Females, 60–79	2	141	0	0.084 (0.075 - 0.094)	0.038 (0.030 - 0.046)	0.079 (0.074 - 0.085)	0.13 (0.094 - 0.16)	x

a Breakdown by sex for the 3–5 year old age group is not recommended.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

x Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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APPENDIX A

ACRONYMS AND ABBREVIATIONS

2,4,5-T	2,4,5-trichlorophenoxyacetic acid
2,4,5-TCP	2,4,5-trichlorophenol
2,4,6-TCP	2,4,6-trichlorophenol
2,4-D	2,4-dichlorophenoxyacetic acid
2,4-DCP	2,4-dichlorophenol
2,5-DCP	2,5-dichlorophenol
3-PBA	3-phenoxybenzoic acid
4-F-3-PBA	4-fluoro-3-phenoxybenzoic acid
AM	atrazine mercapturate
BBP	benzyl butyl phthalate
BPA	bisphenol A
CASRN	Chemical Abstract Services Registry Number
CEPA 1999	*Canadian Environmental Protection Act, 1999*
CHMS	Canadian Health Measures Survey
CI	confidence interval

cis-DBCA	*cis*-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid
cis-DCCA	*cis*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid
CV	coefficient of variation
DACT	diaminochlorotriazine
D*n*BP	di-*n*-butyl phthalate
DCHP	dicyclohexyl phthalate
DDT	dichlorodiphenyltrichloroethane
DEA	desethylatrazine
DEDTP	diethyldithiophosphate
DEHP	di-2-ethylhexyl phthalate
DEP	diethyl phthalate
DEP	diethylphosphate
DETP	diethylthiophosphate
DiBP	di-isobutyl phthalate

continued on the next page

DiNP	di-isononyl phthalate
DMA	dimethylarsinic acid
DMDTP	dimethyldithiophosphate
DMP	dimethyl phthalate
DMP	dimethylphosphate
DMTP	dimethylthiophosphate
DOP	di-*n*-octyl phthalate
EDTA	ethylenediaminetetraacetic acid
EPA	United States Environmental Protection Agency
GM	geometric mean
IARC	International Agency for Research on Cancer
ICP-MS	inductively coupled plasma – mass spectrometry
INSPQ	l'Institute national de santé publique du Québec
IOM	Institute of Medicine
LOD	limit of detection
M*n*BP	mono-*n*-butyl phthalate
MBzP	mono-benzyl phthalate
MCHP	mono-cyclohexyl phthalate
MCPP	mono-3-carboxypropyl phthalate
MEC	mobile examination centre
MEHHP	mono-(2-ethyl-5-hydroxyhexyl) phthalate
MEHP	mono-2-ethylhexyl phthalate
MEOHP	mono-(2-ethyl-5-oxohexyl) phthalate
MEP	mono-ethyl phthalate
MiBP	mono-isobutyl phthalate

MiNP	mono-isononyl phthalate
MMA	monomethylarsonic acid
MMP	mono-methyl phthalate
MMT	methylcyclopentadienyl manganese tricarbonyl
MOP	mono-*n*-octyl phthalate
MRM	multiple reaction monitoring
PAH	polycyclic aromatic hydrocarbon
PCP	pentachlorophenol
PFAS	perfluoroalky substance
PFBA	perfluorobutanoic acid
PFBS	perfluorobutane sulfonate
PFDA	perfluorodecanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexane sulfonate
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PFUnDA	perfluoroundecanoic acid
PMRA	Pest Management Regulatory Agency
PVC	polyvinyl chloride
S-PMA	*S*-phenylmercapturic acid
t,t-MA	*trans,trans*-muconic acid
trans-DCCA	*trans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid
UNEP	United Nations Environment Programme
UPLC	ultra performance liquid chromatography

APPENDIX B

LIMITS OF DETECTION

Laboratory analyses of environmental chemicals and creatinine were performed at the human toxicology laboratory of the Institut national de santé publique du Québec (INSPQ), Québec. INSPQ followed standardized operating procedures that were developed for every assay and technique performed in its laboratory. The laboratory is accredited under ISO 17025. For this report, the limit of detection (LOD) is defined as the minimum concentration of the chemical that is greater than zero and is measured and reported at 99% statistical confidence level. It is estimated based on the United States Environmental Protection Agency protocol (EPA 40 CFR 136).

	Cycle 1	Cycle 2
Metals and Trace Elements in Blood		
Cadmium	0.04 µg/L	0.04 µg/L
Cobalt	—	0.04 µg/L
Copper	0.6 µg/L	20 µg/L
Lead	0.02 µg/dL	0.1 µg/dL
Manganese	0.05 µg/L	0.5 µg/L
Mercury	0.1 µg/L	0.1 µg/L
Molybdenum	0.1 µg/L	0.1 µg/L
Nickel	0.4 µg/L	0.3 µg/L
Selenium	8 µg/L	20 µg/L
Silver	—	0.05 µg/L
Uranium	0.005 µg/L	0.007 µg/L
Zinc	0.0007 mg/L	100 mg/L
Metals and Trace Elements in Urine		
Antimony	0.02 µg/L	0.02 µg/L
Arsenic, total	0.5 µg/L	0.7 µg/L
Arsenite	—	1 µg/L
Arsenate	—	1 µg/L
MMA	—	1 µg/L
DMA	—	1 µg/L
Arsenocholine Arsenobetaine	—	2 µg/L
Cadmium	0.09 µg/L	0.07 µg/L
Cesium	—	0.1 µg/L
Cobalt	—	0.06 µg/L
Copper	0.3 µg/L	0.6 µg/L
Fluoride	—	20 µg/L
Lead	0.1 µg/L	0.2 µg/L
Manganese	0.05 µg/L	0.2 µg/L
Molybdenum	0.1 µg/L	1 µg/L
Nickel	0.2 µg/L	0.3 µg/L
Selenium	6 µg/L	4 µg/L
Silver	—	0.1 µg/L
Thallium	—	0.02 µg/L
Tungsten	—	0.2 µg/L
Uranium	0.01 µg/L	0.01 µg/L
Vanadium	0.1 µg/L	0.1 µg/L
Zinc	10 µg/L	10 µg/L

Benzene Metabolites

Phenol	—	0.1 mg/L
t,tr-MA	—	0.8 µg/L
S-PMA	—	0.08 µg/L

Chlorophenols

2,4-DCP	0.3 µg/L	0.3 µg/L
2,5-DCP	—	0.3 µg/L
2,4,5-TCP	—	0.5 µg/L
2,4,6-TCP	—	1 µg/L
PCP	—	0.7 µg/L

Environmental Phenols and Triclocarban

Bisphenol A	0.2 µg/L	0.2 µg/L
Triclocarban	—	1 µg/L
Triclosan	—	3 µg/L

Nicotine Metabolite

Cotinine	1 µg/L	1 µg/L

Perfluoroalkyl Substances

PFBA	—	0.5 µg/L
PFHxA	—	0.1 µg/L
PFOA	0.3 µg/L	0.1 µg/L
PFNA	—	0.2 µg/L
PFDA	—	0.1 µg/L
PFUnDA	—	0.09 µg/L
PFBS	—	0.4 µg/L
PFHxS	0.3 µg/L	0.2 µg/L
PFOS	0.3 µg/L	0.3 µg/L

Pesticides

Atrazine Metabolites		
AM	—	0.03 µg/L
DACT	—	1 µg/L
DEA	—	0.2 µg/L
Carbamate Metabolites		
Carbofuranphenol	—	0.1 µg/L
2-Isopropoxyphenol	—	0.05 µg/L
2,4-Dichlorophenoxyacetic Acid		
2,4-D	0.2 µg/L	0.2 µg/L
Organophosphate Metabolites[a]		
DMP	0.8 µg/L	1 µg/L
DMTP	0.6 µg/L	0.6 µg/L
DMDTP	0.09 µg/L	0.3 µg/L
DEP	0.5 µg/L	1 µg/L
DETP	0.08 µg/L	0.3 µg/L
DEDTP	0.06 µg/L	0.3 µg/L
Pyrethroid Metabolites		
4-F-3-PBA	0.008 µg/L	0.008 µg/L
cis-DBCA	0.006 µg/L	0.006 µg/L
cis-DCCA	0.007 µg/L	0.007 µg/L
trans-DCCA	0.01 µg/L	0.01 µg/L
3-PBA	0.01 µg/L	0.01 µg/L

[a] LODs for cycle 1 (2007–2009) have been updated from those reported in the first *Report on Human Biomonitoring of Environmental Chemicals in Canada.*

Phthalate Metabolites

MBzP	0.2 µg/L	0.05 µg/L
M*n*BP	0.2 µg/L	0.2 µg/L
MCHP	0.2 µg/L	0.09 µg/L
MEP	0.5 µg/L	0.3 µg/L
MiBP	—	0.1 µg/L
MiNP	0.4 µg/L	0.3 µg/L
MMP	5 µg/L	5 µg/L
MOP	0.7 µg/L	0.3 µg/L
MCPP	0.2 µg/L	0.06 µg/L
MEHP	0.2 µg/L	0.08 µg/L
MEOHP	0.2 µg/L	0.1 µg/L
MEHHP	0.4 µg/L	0.4 µg/L

Polycyclic Aromatic Hydrocarbon Metabolites

Benzo[*a*]pyrene Metabolite		
3-Hydroxybenzo[*a*]pyrene	—	0.002 µg/L
Chrysene Metabolites		
2-Hydroxychrysene	—	0.004 µg/L
3-Hydroxychrysene	—	0.003 µg/L
4-Hydroxychrysene	—	0.003 µg/L
6-Hydroxychrysene	—	0.006 µg/L
Fluoranthene Metabolite		
3-Hydroxyfluoranthene	—	0.008 µg/L
Fluorene Metabolites		
2-Hydroxyfluorene	—	0.003 µg/L
3-Hydroxyfluorene	—	0.001 µg/L
9-Hydroxyfluorene	—	0.003 µg/L
Naphthalene Metabolites		
1-Hydroxynapththalene	—	0.1 µg/L
2-Hydroxynapththalene	—	0.05 µg/L
Phenanthrene Metabolites		
1-Hydroxyphenanthrene	—	0.005 µg/L
2-Hydroxyphenanthrene	—	0.003 µg/L
3-Hydroxyphenanthrene	—	0.003 µg/L
4-Hydroxyphenanthrene	—	0.001 µg/L
9-Hydroxyphenanthrene	—	0.004 µg/L
Pyrene Metabolite		
1-Hydroxypyrene	—	0.002 µg/L

Adjustment Factor

Creatinine	0.3 mmol/L (4 mg/dL)	0.4 mmol/L (5 mg/dL)

APPENDIX C

CONVERSION FACTORS

Units of measurement are important. Results are reported here using standard units; however, units can be converted using the conversion factors presented below for comparison of data with other data sets.

Unit	Abbreviation	Value
litre	L	—
decilitre	dL	10^{-1} L
millilitre	mL	10^{-3} L
microlitre	µL	10^{-6} L
gram	g	—
milligram	mg	10^{-3} g
microgram	µg	10^{-6} g
nanogram	ng	10^{-9} g
picogram	pg	10^{-12} g

Data can be converted from µg/L to µmol/L using the molecular weight (MW) of the chemical using the formula:

X µmol/L = X µg/L x conversion factor (CF), where the CF is equivalent to 1/MW.

	MW (g/mol)	CF (µg/L → µmol/L)
Metals and Trace Elements		
Antimony	121.76	0.00821
Arsenic	74.92	0.01335
Arsenite	125.94	0.00794
Arsenate	141.94	0.00705
MMA	139.97	0.00714
DMA	138.00	0.00725
Arsenocholine Arsenobetaine	178.06	0.00562
Cadmium	112.41	0.00890
Cesium	132.91	0.00752
Cobalt	58.93	0.017
Copper	63.55	0.01574
Fluoride	19.00	0.0526
Lead – blood – urine	207.20	0.0483[a] 0.00483
Manganese	54.94	0.0182
Mercury	200.59	0.00499
Molybdenum	95.94	0.0104
Nickel	58.69	0.017
Selenium	78.96	0.0127
Silver	107.87	0.00927
Thallium	204.38	0.00489
Tungsten	183.84	0.00544
Uranium	238.03	0.0042
Vanadium	50.94	0.0196
Zinc – blood – urine	65.39	15.3[b] 0.0153

[a] Lead CF from µg/dL →µmol/L

[b] Zinc CF from mg/L →µmol/L

Benzene Metabolites

Phenol	94.11	10.6[a]
t,tr-MA	142.11	0.00704
S-PMA	239.29	0.00418

a Phenol CF from mg/L →µmol/L

Chlorophenols

2,4-DCP	163.00	0.00613
2,5-DCP	163.00	0.00613
2,4,5-TCP	197.45	0.00506
2,4,6-TCP	197.45	0.00506
PCP	266.34	0.00375

Environmental Phenols and Triclocarbon

Bisphenol A	228.29	0.00438
Triclocarban	315.58	0.00317
Triclosan	289.54	0.00345

Nicotine Metabolite

Cotinine	176.22	0.00567

Benzene Metabolites

PFBA	214.04	0.00467
PFHxA	314.05	0.00318
PFOA	414.07	0.00242
PFNA	464.08	0.00215
PFDA	514.08	0.00195
PFUnDA	564.09	0.00177
PFBS	300.10	0.00333
PFHxS	400.11	0.00250
PFOS	500.13	0.00200

Pesticides

Atrazine Metabolites		
AM	342.42	0.00292
DACT	145.55	0.00687
DEA	187.63	0.00533
Carbamate Metabolites		
Carbofuranphenol	164.20	0.00609
2-Isopropoxyphenol	152.19	0.00657
2,4-Dichlorophenoxyacetic Acid		
2,4-D	221.04	0.00452
Organophosphate Metabolites		
DMP	126.05	0.00793
DMTP	142.11	0.00704
DMDTP	158.18	0.00632
DEP	154.10	0.00649
DETP	170.17	0.00588
DEDTP	186.24	0.00537
Pyrethroid Metabolites		
4-F-3-PBA	232.21	0.00431
cis-DBCA	297.97	0.00336
cis-DCCA	209.07	0.00478
trans-DCCA	209.07	0.00478
3-PBA	214.22	0.00467

Phthalate Metabolites

MBzP	256.25	0.00390
M*n*BP	222.24	0.00450
MCHP	248.27	0.00403
MEP	194.18	0.00515
MiBP	222.24	0.00450
MiNP	292.37	0.00342
MMP	180.16	0.00555
MOP	278.34	0.00359
MCPP	252.22	0.00396
MEHP	278.34	0.00359
MEOHP	292.33	0.00342
MEHHP	294.34	0.00340

Polycyclic Aromatic Hydrocarbon Metabolites		
Benzo[*a*]pyrene Metabolite		
3-Hydroxybenzo[*a*]pyrene	268.31	0.00373
Chrysene Metabolites		
2-Hydroxychrysene	244.29	0.00409
3-Hydroxychrysene	244.29	0.00409
4-Hydroxychrysene	244.29	0.00409
6-Hydroxychrysene	244.29	0.00409
Fluoranthene Metabolite		
3-Hydroxyfluoranthene	218.25	0.00458
Fluorene Metabolites		
2-Hydroxyfluorene	182.22	0.00549
3-Hydroxyfluorene	182.22	0.00549
9-Hydroxyfluorene	182.22	0.00549
Naphthalene Metabolites		
1-Hydroxynapththalene	144.17	0.00694
2-Hydroxynapththalene	144.17	0.00694
Phenanthrene Metabolites		
1-Hydroxyphenanthrene	194.23	0.00515
2-Hydroxyphenanthrene	194.23	0.00515
3-Hydroxyphenanthrene	194.23	0.00515
4-Hydroxyphenanthrene	194.23	0.00515
9-Hydroxyphenanthrene	194.23	0.00515
Pyrene Metabolite		
1-Hydroxypyrene	218.25	0.00458

Adjustment Factor		
Creatinine	113.18	88.4[a]

a Creatinine CF from mg/L →µmol/L

APPENDIX D

CREATININE

Creatinine (cycle 1, 2007–2009)

Creatinine — Geometric means and selected percentiles of urine concentrations (mg/dL) for the Canadian population aged 6–79 years by sex and age group, Canadian Health Measures Survey cycle 1 (2007–2009).

Group (years)	Cycle	n	%<LOD[a]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total 6–79 years	1	5515	0.22	83 (78 - 89)	27 (23 - 30)	93 (86 - 99)	140 (140 - 150)	250 (240 - 260)
Total 6–11 years	1	1042	0.29	66 (60 - 72)	24 (18 - 29)	74 (67 - 81)	110 (98 - 110)	170 (160 - 180)
Total 12–19 years	1	992	0.10	120 (110 - 130)	39 (30 - 47)	130 (120 - 140)	190 (170 - 200)	300 (260 - 330)
Total 20–39 years	1	1172	0.34	90 (81 - 100)	29 (22 - 36)	99 (91 - 110)	160 (150 - 170)	280 (250 - 300)
Total 40–59 years	1	1221	0.25	78 (73 - 84)	24 (19 - 28)	86 (76 - 96)	140 (130 - 150)	240 (230 - 250)
Total 60–79 years	1	1088	0.09	72 (68 - 75)	26 (22 - 31)	81 (77 - 84)	120 (110 - 120)	190 (170 - 220)
Males 6–79 years	1	2663	0.26	100 (96 - 110)	36 (28 - 43)	110 (100 - 110)	160 (150 - 170)	260 (250 - 280)
Males 6–11 years	1	526	0.38	66 (57 - 78)	24^{E} (15 - 34)	73 (64 - 82)	100 (96 - 110)	170 (160 - 180)
Males 12–19 years	1	505	0.20	120 (110 - 130)	44 (31 - 58)	130 (120 - 140)	180 (170 - 200)	280 (250 - 310)
Males 20–39 years	1	515	0.39	110 (95 - 120)	33^{E} (17 - 50)	120 (100 - 140)	190 (170 - 210)	290 (270 - 310)
Males 40–59 years	1	575	0.35	100 (96 - 110)	36 (27 - 44)	110 (97 - 120)	170 (140 - 200)	250 (240 - 260)
Males 60–79 years	1	542	0	95 (88 - 100)	43 (37 - 48)	100 (89 - 110)	140 (130 - 150)	210 (190 - 220)
Females 6–79 years	1	2852	0.18	68 (62 - 74)	22 (18 - 25)	75 (66 - 84)	120 (110 - 130)	210 (200 - 230)
Females 6–11 years	1	516	0.19	65 (59 - 71)	22 (17 - 28)	76 (65 - 87)	110 (97 - 120)	170 (150 - 190)
Females 12–19 years	1	487	0	110 (98 - 130)	36 (23 - 49)	130 (120 - 140)	190 (170 - 210)	320 (260 - 380)
Females 20–39 years	1	657	0.30	74 (67 - 83)	25 (19 - 31)	80 (68 - 92)	130 (110 - 140)	220 (200 - 240)
Females 40–59 years	1	646	0.15	60 (54 - 67)	19 (15 - 23)	66 (54 - 78)	110 (100 - 120)	190 (170 - 210)
Females 60–79 years	1	546	0.18	55 (49 - 62)	20 (15 - 25)	55 (47 - 64)	93 (86 - 100)	150 (140 - 170)

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Creatinine (cycle 2, 2009–2011)

Creatinine — Geometric means and selected percentiles of urine concentrations (mg/dL) for the Canadian population aged 3–79 years by sex and age group[a], Canadian Health Measures Survey cycle 2 (2009–2011).

Group (years)	Cycle	n	%<LOD[b]	GM (95%CI)	10th (95%CI)	50th (95%CI)	75th (95%CI)	95th (95%CI)
Total 3–79 years	2	6299	0.10	100 (100 - 110)	35 (33 - 38)	110 (110 - 120)	170 (160 - 180)	290 (270 - 300)
Total 3–5 years	2	572	0	59 (55 - 63)	27 (24 - 29)	61 (55 - 67)	86 (78 - 94)	130 (110 - 150)
Total 6–11 years	2	1059	0.19	88 (83 - 94)	37 (33 - 42)	100 (93 - 110)	130 (120 - 130)	190 (170 - 210)
Total 12–19 years	2	1042	0.10	130 (120 - 150)	52 (36 - 68)	150 (140 - 160)	210 (190 - 220)	300 (270 - 330)
Total 20–39 years	2	1322	0.08	120 (110 - 130)	37 (26 - 48)	140 (130 - 150)	200 (190 - 210)	320 (270 - 380)
Total 40–59 years	2	1223	0.16	100 (96 - 110)	33 (26 - 40)	110 (110 - 120)	180 (160 - 190)	280 (260 - 310)
Total 60–79 years	2	1081	0	85 (80 - 89)	31 (26 - 36)	97 (89 - 100)	140 (130 - 150)	230 (200 - 250)
Males 3–79 years	2	3031	0.13	120 (120 - 130)	47 (42 - 52)	130 (120 - 140)	200 (180 - 210)	310 (280 - 330)
Males 6–11 years	2	530	0.38	92 (84 - 100)	43 (34 - 53)	100 (95 - 110)	130 (120 - 130)	180 (160 - 200)
Males 12–19 years	2	542	0.18	150 (130 - 160)	69 (57 - 82)	150 (140 - 170)	210 (190 - 240)	300 (270 - 340)
Males 20–39 years	2	551	0.18	140 (130 - 160)	52 (40 - 65)	160 (150 - 170)	220 (200 - 250)	400 (330 - 470)
Males 40–59 years	2	615	0	120 (110 - 140)	43 (29 - 56)	140 (120 - 160)	210 (190 - 230)	300 (280 - 330)
Males 60–79 years	2	504	0	100 (95 - 110)	44 (36 - 51)	110 (110 - 120)	150 (140 - 160)	250 (220 - 290)
Females 3–79 years	2	3268	0.06	90 (85 - 94)	30 (28 - 32)	100 (96 - 110)	150 (140 - 160)	250 (230 - 270)
Females 6–11 years	2	529	0	85 (79 - 91)	34 (31 - 37)	97 (88 - 100)	130 (120 - 130)	210 (180 - 230)
Females 12–19 years	2	500	0	120 (110 - 130)	41 (30 - 52)	140 (130 - 150)	200 (180 - 220)	290 (270 - 320)
Females 20–39 years	2	771	0	100 (90 - 120)	30 (22 - 39)	120 (110 - 130)	170 (150 - 190)	270 (220 - 320)
Females 40–59 years	2	608	0.33	87 (79 - 96)	29 (24 - 34)	98 (90 - 110)	140 (130 - 150)	220 (200 - 250)
Females 60–79 years	2	577	0	71 (65 - 77)	24 (18 - 30)	78 (69 - 87)	120 (110 - 130)	200 (170 - 220)

[a] Breakdown by sex for the 3–5 year old age group is not recommended.

[b] If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.